Engineering Library

ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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See half-page Advertisement page 76, April 20.

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TENDERS.

THE GREAT INDIAN PENINSULA RAILWAY COMPANY.

The Directors are prepared to receive

Tenders for the Supply of the following STORES, namely:—

HELICAL SPRINGS.

Specifications and Forms of Tender may be obtained at this office on payment of the fee for the Specification, which payment will not be returned.

Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned, marked "Tender for Helical Springs," or, as the case may be, not later than Eleven o'clock a.m., on Thursday, the 17th May, 1917.

The Directors do not bind themselves to accept the lowest or any Tender.

R. H. WALPOLE,
Secretary.

Company's Offices,
48, Copthall Avenue, E.C., London,
9th May, 1917. G 762

IN THE MATTER OF THE TRADING WITH THE ENEMY AMENDMENT ACT, 1916.

The PUBLIC TRUSTEE invites

Tenders for the Purchase of the Whole or any part of 119,660 Shares of £5 each, fully paid, in SIEMENS BROTHERS & COMPANY, LIMITED, vested in him as Custodian by an Order made by the Board of Trade, in pursuance of Section 4 of the Trading with the Enemy Amendment Act, 1916, and dated 9th August, 1916.

The issued capital of the Company consists of 120,000 Shares of £5 each, fully paid.

The purchasers, who must be British-born subjects, will be required to make a sworn Declaration as to nationality and freedom from foreign control on a form to be obtained from the Offices of the Public Trustee.

The purchasers will also be required to satisfy the Public Trustee as to their financial and technical ability to carry on the business of the Company as efficiently as heretofore, or otherwise to the satisfaction of the Government.

A report upon the Company's operations and affairs has been prepared by the Company, in conjunction with the Company's Auditors (Messrs. PRICE, WATERHOUSE & Co.), and with Messrs. TURQUAND, YOUNGS & Co. Copies of this report can be obtained, subject as hereinafter mentioned, together with copies of Company's accounts up to the 31st December, 1915, on written application to the Public Trustee, Kingsway, W.C.

All applicants will be required to satisfy the Public Trustee as to any matter which he may think fit to investigate before copies of such Report or accounts will be supplied.

Intending Tenderers who desire to inspect the property of the Company, should apply to the Public Trustee for an authority to do so.

Tenders must be delivered, sealed, to the Public Trustee, Kingsway, W.C., on or before Thursday, the 14th June, 1917 (NOT APRIL 2ND, AS PREVIOUSLY ADVERTISED), at Twelve o'clock Noon, and marked on the envelope, "Tender, Siemens Shares."

The Public Trustee does not bind himself to accept any Tender, and reserves to himself all rights in connection therewith.

Forms of Tender can be obtained from the PUBLIC TRUSTEE.

Dated this 8th day of February, 1917. 5943

C. J. STEWART, Public Trustee,
Custodian for England and Wales.

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Munitions Manufacturers with large turnover REQUIRE a SALES MANAGER to develop a light engineering business after the war. Trade influence and connection necessary and preference given to one who can introduce specialities in manufactures. Splendid opportunity for the right man. Principals only need apply. — AGAR, BATES, NEAL & CO., Chartered Accountants, Birmingham. G 726

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Wanted, Two Works Super- INTENDENTS for large munitions factory in the Midlands. Must be energetic, and good disciplinarians. Experience with capstan, turret and engine lathes essential, also tooling of same. Only first-class men need apply. State experience and salary required.—Address, G 734, Offices of ENGINEERING.

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No one on Government work need apply.

Apply, by letter only, AUBLET, HARRY AND CO., 52-55, Curtain Road, London, E.C. G 743

Wanted, Immediately, Works REPAIR SUPERINTENDENT in Controlled Establishment in the Midlands. Must be a thoroughly practical man and accustomed to general maintenance of Steel Rolling Mills and plant in connection therewith. Must know how to properly control workmen, and have sound and reliable judgment; six o'clock man essential.—State experience, testimonials and wages required to G 754, Offices of ENGINEERING.

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Chief Engineer Required immediately with sound theoretical and practical knowledge in mechanical and electrical engineering for the completion and running of large factory. Applications will only be considered from ineligible gentlemen who have occupied similar positions, and can furnish excellent testimonials.—Write X., BOX 462, care of JUDD'S, 97, Gresham St., E.C.2. G 751

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Gentleman, with knowledge of Explosive trade and Companies' work, WANTED by London Controlled Firm for administrative duties. Must be ineligible for military service.—Write fully to BOX G 3256, care of DAWSON'S Advertising Agency, 121, Cannon Street, E.C. 4. G 735

Cost Clerk Required at West- minster Offices of a Constructional Engineering Firm (controlled). Must be over military age. Have had previous costing and engineering shop experience. Reply, stating full particulars, age, and salary required. No one employed on Government work nor resident more than ten miles away need apply.—Address, G 701, Offices of ENGINEERING.

Cost Clerk Required for large Engineering Works. No one engaged on Government work or resident more than 10 miles away will be engaged.—Apply, stating age, experience and salary required to WORKS ACCOUNTANT, VICKERS LIMITED, Crayford. G 774

Wanted, Clerk for Time Office and Cost Book, ineligible military service. No person already on Government work will be engaged.—Apply, your nearest EMPLOYMENT EXCHANGE, quoting No. A3194. G 708

Assistant Engineer, about 25 years of age, with sound technical training, to take 6-hour Shifts in the running and maintenance of a Controlled Factory in East London. Must have had similar experience and used to the control of men. No one already employed on Government work will be engaged.—Address, stating age, experience and salary required, to G 691, Offices of ENGINEERING.

Assistant Engineer Required for chemical works in Midlands. Age 23 to 30 preferred, but must be exempt from Military Service. College training and experience on outside contractors' work desirable but not essential. No person engaged on Government work will be employed.—Make detailed, written application to your nearest LABOUR EXCHANGE, mentioning this paper and G 678.

Manager's Assistant (Ineli- gible) REQUIRED by Controlled Firm of Steel Constructional Engineers in the Midlands. Competent in drawing office work, preparation of estimates, tenders, and handling correspondence.—Address, stating age, experience, and salary required, G 689, Offices of ENGINEERING.

A Firm of Patent Agents REQUIRE the services of a TECHNICAL ASSISTANT. One who has had previous experience in a Patent Agent's office preferred.—Write full particulars of experience and salary required to 1826, SELL'S Advertising Offices, Fleet Street, E.C. 4. G 716

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Wanted, Draughtsman for the mechanical design of large electrical direct current machines. Nobody engaged on Government work will be accepted.—Write or apply to the nearest Board of Trade EMPLOYMENT EXCHANGE, mentioning this Journal and No. A 2631. G 457

Mechanical Draughtsman REQUIRED, for large controlled establishment in S.W. London, accustomed to designing special machinery from rough sketches and laying out plant. No one employed on Government work nor resident more than 10 miles away need apply.—Address, stating age, salary and experience, G 714, Offices of ENGINEERING.

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Jig and Tool Draughtsman for aeroplane works near London. Experience in shop lay-out an asset. No person resident more than 10 miles away or already on Government work need apply. State age, salary and experience.—Address, G 746, Offices of ENGINEERING.

Wanted, Machine Shop Fore- MAN for small shop engaged on light repetition work near London. Applicants should state age, experience, and salary required. No one employed on Government work or resident more than 10 miles away will be engaged.—Address, G 745, Offices of ENGINEERING.

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"GROUND ICE" AND WATER SUPPLIES.

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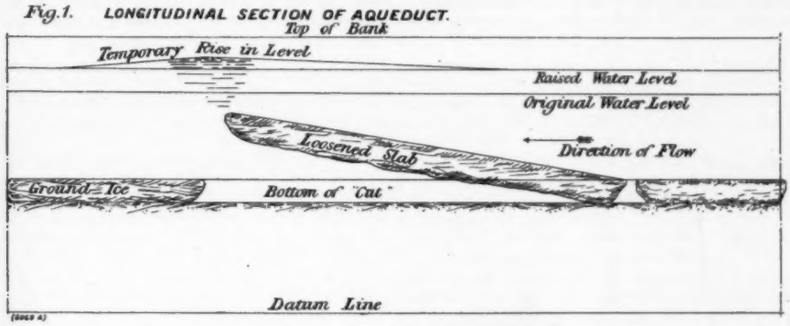
THE formation of "ground ice" or "anchor ice" at the bottom of running streams is not unknown in this country, but its formation in comparatively deep reservoirs to an extent which seriously interferes with water supplies appears to be a somewhat rare occurrence, and consequently is not generally provided for. Apparently, however, under special conditions it assumes such proportions as to warrant serious consideration being given to the subject.

The physical properties of water are well known, and also the changes involved during its transition into ice. Notwithstanding this, there appears to be some considerable difference of opinion as to the cause or causes of ground ice, and this is not unnatural in view of these same physical properties and their apparent violation in the formation of ground ice. Various interesting and suggestive theories have been propounded, such as (*a*) radiation, with the resultant freezing of the water which comes into contact with the surfaces of the bottom which have been cooled below the freezing-point, or, (*b*) the cooling of the water in thin layers until the whole body of water has been transfused within itself and in the process has reached the freezing-point, when the forming of ice begins. It is difficult to find a theory which is supported under all conditions, but the motion or agitation of the water at the surface, which consequently prevents the formation of the ice there, would appear to be an essential condition.

Fig. 1. LONGITUDINAL SECTION OF AQUEDUCT.



Ground ice has been experienced in former years at Greenock in the "Cut," an open aqueduct some five miles in length and situated about 500 ft. above sea-level. The water has a velocity of about 3 ft. per second, and ice sometimes forms on the bottom, thereby raising the surface level of the water. The ice occasionally rises to the surface in slabs, evidently when its buoyancy is sufficient to overcome the adhesive forces tending to hold it down. A slab may take up the position shown in Fig. 1, annexed, and remain in that position for some time if not forcibly released. Consequently careful watching is required, as the slab in the position shown is apt to cause a temporary local rise in the surface of the water, with consequent overflow.

The following statement made in the "Encyclopædia Britannica," viz., "It may be formed under favourable conditions below briskly flowing water, probably by the action of eddies, which draw the surface water down through the warmer but denser liquid, and thus cool the stones and rocks at the bottom," is ingenious, but the writer is inclined to think that the formation of ground ice in this aqueduct, which has a rough bottom, is due to the cooling of the whole mass of water and the ice first forming in the comparatively still water encountered in the lee of stones, &c. The process may be, and probably is, accelerated by radiation, as the portions of the aqueduct where the ice usually forms first are situated at comparatively open spaces and have low banks.

Towards the close of January this year, and, as far as can be ascertained, for the first time in the history of some of the reservoirs, the formation of "ground ice" was general throughout the Greenock Corporation waterworks. A strong, cold, easterly wind sprang up, and the temperature fell to about 30 deg. F. (it may have been less at some of the reservoirs), but the frost was not very keen, and there was little difference between the maximum and minimum temperatures. At various dates between January 23 and 30 eight outlet pipes from different reservoirs, situated at altitudes between 400 ft. and 650 ft. above sea-level, were blocked with ice at depths varying from 3 ft. down to about 40 ft., although there was no ice on the surface of the water. Various remedial measures were adopted. At one reservoir a steam boiler was brought into operation, and a pipe, having an air jacket, was led below the surface of the water down to the mouth of the outlet pipe, as shown in Fig. 2. At another reservoir, where the outlet tower was empty, fires were suspended under the pipes inside, and bags of salt lowered on to the mouth of the pipes outside, as shown in Fig. 3. Unfortunately for ascertaining the efficacy of these measures, although fortunately for the supply to the town, the wind died down shortly afterwards, the temperature lowered, ice began to form on the surface, and the whole of the pipes cleared. Whether the successful clearing was due to the measures taken or to the change in the atmospherical conditions, or both, it was not possible to ascertain definitely.

Fig. 3.

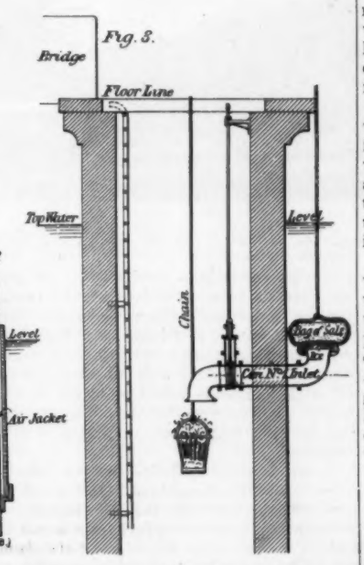
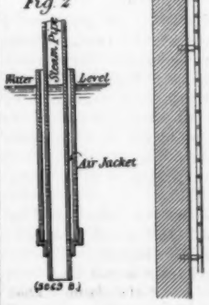


Fig. 2



One of the small reservoirs, 15 ft. in depth and having a 22-in. diameter draw-off pipe, was emptied, and photographs Figs. 4 and 5, Plate XLIV, were taken. Fig. 4 shows the solid block of ground ice (about 10 ft. in diameter and 6 ft. in height) which formed round the screens over the outlet pipe. The figure is standing on the top of the screens, and the top water-level is clearly indicated by the mark of the ice on the gauge rod. Fig. 5 gives another view of the block and shows the remarkable formation of the ice. The photograph, which was taken looking in a westerly direction, also shows the coating of ice all over the bottom and sides of the reservoir. It is probable, if not certain, that the block of ice over the outlet was formed by pieces of ground ice which became gradually detached from the bottom of the reservoir and were drawn by the current of water down to the outlet at the screens. Before this reservoir was emptied no ice could be observed at the surface, and even when the water was down to near the level of the top of the block of ice the screens could be distinctly seen through the ice, which was then quite transparent, and did not turn white and opaque until exposed to the air.

Fig. 6 shows the ice on one of the filters projecting through the water as it was being lowered. Fig. 7 is a view of another filter with the water completely run off, and shows clearly the remarkable apparent "growth" of the ice. The figure is standing on the surface of the sand. During practically the whole of the period under review the sky was overcast, with snow threatening, and there was considerable wave-motion on the surfaces of all the reservoirs.

The ice which formed in the main aqueduct, or "Cut," was of a soft spongy nature, and might be best described as sodden snow. Frequently it rose to the surface in comparatively small pieces, which on coming into contact with the gratings of the draw-off became solid ice. Similar species of ice were observed in some of the reservoirs, while, on the other hand, in the reservoir which was emptied, and also on the filters, the ice grew up from the ground in thin vertical leaves somewhat similar to sheets of glass, and these were generally attached to stones like bunches of flowers.

At Huddersfield, on January 26, considerable trouble with ground ice was experienced at the Blackmoorfoot reservoir, about 40 ft. in depth, and also in the clean water reserve tank, 10 ft. in depth. The outlets at both places became blocked with ice, and the services of a diver had to be requisitioned to help to clear that at the reservoir.

It is worth noting that at Carleton, a district of St. John, New Brunswick, a sudden stoppage of the water supply in 1882 was attributed to anchor ice,* but the occurrence was evidently different from that experienced at Greenock recently, although somewhat similar in its results. At Carleton, where the temperature of the air fell suddenly to 10 deg. F., the ice was about 6 in. thick on the surface of the reservoir, and the block (about the size of a barrel) which formed round the outlet was described as a kind of slush or minute particles of congealed water, evidently of a somewhat similar nature to that found in the "Cut" at Greenock.

In view of the foregoing, the question as to whether ground ice should be taken into account in the design and administration of waterworks would appear to be well worthy of consideration, as although a recurrence of the conditions may not take place in the near future, it may occur at a time, and to such an extent, as to cause great inconvenience.

It does not appear to be a matter which could very well be provided for in the design of waterworks, at least to any great extent, but evidently it would be desirable to have remedial measures prepared beforehand. Undoubtedly the recent experience at Greenock gives an indication of the atmospherical and meteorological conditions when ground ice might be expected to form, and the writer hopes the foregoing notes may be of use to those engaged in the design or having charge of waterworks in this country.

COPPER, ALUMINIUM, ZINC AND IRON WINDINGS FOR DYNAMOS.—Professor R. Richter, of Carlsruhe, has recently experimented on the comparative merits of copper, aluminium, zinc and iron wire windings for dynamos, with these results:—Taking copper-wire windings as a standard, the loss of efficiency to a dynamo with windings of aluminium is from 1½ to 2 per cent; with zinc wire, 3 to 6 per cent., while with iron wire this loss is from 8 to 12 per cent. Against this he finds that at pre-war prices of metal a dynamo with aluminium windings will be 3 per cent. cheaper than one with copper windings, whilst those with zinc and iron windings would be, respectively, 50 and 62 per cent. more expensive. He concludes by saying that this may lead to the more extensive use of aluminium in Germany for electromotors, &c., as he expects that the production of aluminium could be increased to any required extent. What justification he has for these last remarks he does not say; they are probably based more on hopes than on actual facts.

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* "Anchor Ice on a Water Main," by J. B. Francis. Transactions of the American Society of Civil Engineers, 1887, page 171.

AMERICAN WOODEN SAILING SHIPS WITH AUXILIARY MOTORS.

WITH the definite decision of the United States to enter the European war there has naturally been much speculation as to the direction in which the vast manufacturing resources of that country could be most rapidly and profitably employed for the achievement of a speedy and lasting peace. As the results achieved by the Germanic powers in the prosecution of their submarine campaign of ruthless destruction of all vessels at sight constitute a serious and growing menace to the essential shipping of the Entente Powers, as well as to that of neutrals, it is not surprising that one of the first acts of the United States Government should be directed toward countering the effects of this hostile submarine activity. Two main lines of action are possible, and each is essential, viz., to combat and destroy the submarines, and to provide new tonnage to replace losses. It is to the latter of these that particular attention is being devoted by the shipbuilders of America. The urgent necessity for the building of new merchant tonnage has been insisted on for a considerable time past, and in this country the situation is being met by the construction of a large number of vessels of suitable size and speed and in the design and construction of which the principle of standardisation of hulls and machinery has been uniformly adopted. In America a Shipping Board has been formed with the object of arranging for the building of a fleet of 1,000 ocean-going wooden ships fitted with sails and with internal combustion engines, and capable of undertaking general cargo carrying service.

It is estimated that the first of these vessels, each one of which will be capable of carrying about 2,500 tons of cargo, will be ready for delivery in five months, and that from the beginning of October next the output can be maintained at the rate of 200,000 tons per month, equivalent to an output of between two and three ships per day. Such an enormous output can only be attained under the highest system of organisation and with an ample supply of material and labour guaranteed. With regard to the organisation of industry for rapid output the American nation has little to learn, and the fact that Colonel Goethals—the administrative constructor of the Panama Canal—is suggested as head of the Shipping Board should ensure the successful solution of the administrative problems. No difficulty will arise in regard to the provision of material for hull construction, as the yards on the Pacific coast are practically in the midst of the best timber-producing country, and transport to the Atlantic seaboard will easily be overtaken by the transcontinental railways. Labour presents a more difficult problem, owing to the unprecedented demand which will be made for men with the requisite training and experience in the construction of wooden vessels, but bearing in mind the results achieved in this country by the employment of unskilled labour and women on munitions work and in shipyards, the solution of the difficulty arising from a shortage of carpenters should present no serious obstacle to the adaptable American workers. Standardisation of sizes of timber used will enable the sawmills to turn out the required material rapidly and economically, while the use of the modern power tools, such as pneumatic drills, band saws, &c., will be of very material assistance in the reduction of labour, and consequently in the time of construction. The provision of suitable heavy oil engines in sufficient quantities to meet the anticipated rate of building hulls may at first present some difficulties, as two engines of about 240 h.p. each will be required for each vessel, but the engineering resources of the country are such that this should be only a temporary difficulty. The provision of suitable armament is at present regarded as the most effective protection for low-speed merchant vessels, and in this respect there is no reason why the wooden vessels should be inferior to steel vessels, as suitable stiffening for the guns can be equally well arranged for. It is, however, on efficient subdivision by means of watertight bulkheads that we must rely for keeping a badly damaged vessel afloat, and the subdivision of wooden ships to the same extent as steel ships is not practicable, nor has it been necessary in the past. Under present conditions, where the main purpose for which the wooden vessels are being built is the carrying of such foodstuffs as are practically certain to be destroyed by contact with sea water, the provision of extra bulkheads would seem to be a desirable feature in view of the possibility of only local damage due to gunfire or striking a mine being sustained.

It has been claimed that wooden vessels will be less vulnerable to torpedo and shell attack than steel vessels of the same size, but it is difficult to discover a reasonable basis to support the claim. That it is difficult to sink a wooden ship in the light condition or loaded with a cargo of low specific gravity is obvious, but total or partial destruction of the hull would serve the purpose of the U-boat commander equally well so long as the cargo did not reach its destination. That torpedo attack or gunfire will accomplish the required degree of destruction in the case of the wooden vessel at least as readily as in the case of steel vessels does not seem open to reasonable doubt, and the success of the wooden boats must be looked for in numbers, armament and handiness rather than in any special virtue due to material of construction.

The type, method of construction and scantlings of the proposed vessels are clearly shown by the drawings reproduced in Figs. 2 to 17, on Plate XLV, while the view Fig. 1, annexed, shows four vessels of similar type in various stages of completion on the stocks at the yard of the Puget Sound Bridge and Dredging Company. There is not now in Britain any definite standard of construction for wooden vessels of the sizes now being dealt with, and comparison must therefore be made with the scantlings and constructions of former days. Fig. 8, Plate XLV, shows the midships section of a vessel 268 ft. long between perpendiculars, 46 ft. 10 in. moulded beam, and 26 ft. 9 in. moulded depth, and may be taken as typical of the construction and scantlings to be worked to in the vessels now being built. Reference to the figure will show that the construction is very strong throughout and particularly as regards the disposition of the timber, the sizes of frames, and thickness of ceiling. In regard to each of these items the scantlings are in excess of the British practice of former times. The filling frames are carried a much shorter distance up toward the bilge than was formerly the case, but this is amply compensated for by the increased scantling of the frames and thickness of ceiling. The method of securing together the logs comprising the keel, centre girder, and frames is clearly shown in Figs. 13, 14 and 15. It will be seen that the centre girder, which takes the place of the vertical keel and rider plate in a modern steel vessel, consists of eight logs 20 in. by 20 in. and a top log or rider 20 in. by 24 in. thoroughly bolted together and to the frames and keel and worked in lengths of about 106 ft. The various lengths of timber are longitudinally connected together by the usual diagonally cut scarfed joints 10 ft. 8 in. long, a good shift of butts being provided, as shown in Fig. 2. This whole structure is continued throughout the length of the vessel and is scarfed into and bolted to the structures comprising the stem and sternpost, thus forming an extremely rigid "backbone" for the whole of the hull structure and capable of withstanding the severe vertical and transverse stresses which are set up in a seaway. To those familiar with the construction of stems and sternposts in older wooden vessels, a reference to Fig. 2 will show how greatly the construction of these important parts has been simplified by the substitution of a comparatively small number of practically straight pieces for the intricate collection of oddly shaped pieces known as stemson, sternson, deadwood, aprons, stems, gripes, chocks, lace pieces, &c., which formerly were grouped together to form stems and sternposts.

From the midships section, Fig. 8, it will be seen that the frames are composed of five or six pieces, worked double, and vary in depth from 26½ in. at keel to 17½ in. at turn of bilge, 10 in. at deck and 9 in. at rail. Beam knees 4 ft. 6 in. by 6 ft. deep and 12 in. thick connect the beams to the frames and form the main item of resistance to transverse racking stresses. These knees are of extreme importance in sailing vessels, owing to the fact that they have to resist the racking stresses set up by

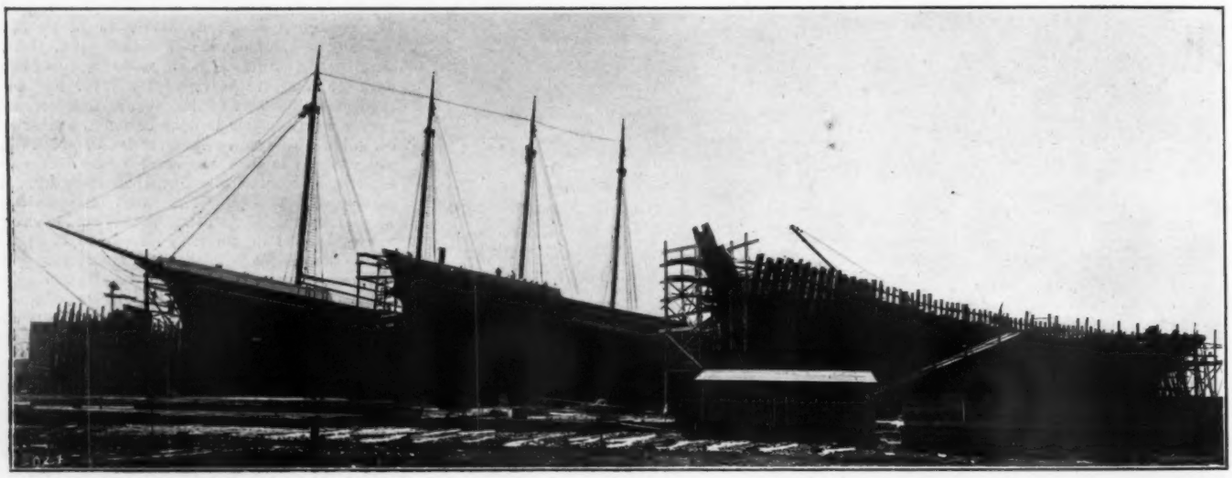


FIG. 1. WOODEN SHIPS IN PROGRESS AT THE YARD OF THE PUGET SOUND BRIDGE AND DREDGING COMPANY.

the wind pressure on the sails and communicated to the deck through the mast wedging, as well as the transverse stresses due to rolling in a seaway, and in this way have to undertake the duties performed by bulkheads, partial bulkheads and web frames in steel vessels. As it is intended to fit oil engines driving twin screws in these vessels, provision is made for engine seating aft and for the accommodation of oil storage tanks, as shown in Figs. 3 and 4. A donkey boiler providing steam for six cargo winches and a windlass is installed at the after end of the forecastle. Figs. 5, 6 and 7 show the details of the sails and rigging of the vessels as arranged for four and five-masted fore-and-aft schooners respectively. This form of rig has several advantages over square rig, the principal being the simplification of masts and spars, lesser amount of standing and running rigging required, and greater ease in the handling—the latter being an important advantage in view of the fact that a smaller crew can be carried. Figs. 9 and 10 show an athwartship and fore-and-aft elevation, and Figs. 11 and 12 sections of the mast partners and wedging respectively.

It will be seen that the wooden vessels are of a strong and useful type, and if produced in sufficient numbers and at the rate anticipated should do much to ease the situation created by recent losses. As elaborate machinery is not essential to the building of these vessels it should be possible for a very large number of shipbuilding firms to undertake their construction, and as delay owing to lack of raw material is hardly likely to occur there should be every prospect of rapid and sustained output. If in addition to this the Control Board insists that the yards building these wooden vessels shall undertake no other work, and appoints only thoroughly competent overseers, with wide discretionary powers for the immediate settlement of such constructional points as must inevitably occur during building, the problem of output will be rendered comparatively simple. That the success of the scheme depends almost entirely on the maintenance of a high rate of construction is at once apparent from a glance at the probabilities behind the most recently published official tables giving the losses of British merchant vessels for two consecutive weeks. The loss in tonnage for each of these weeks, even when there is added to it the losses in the corresponding period by the other belligerent and neutral nations, gives confidence in believing that the estimated rate of completion of new tonnage represented by the wooden ships—about 50,000 tons per week—will go some way, along with the production of steel ships, to rectify the balance. The earnestness with which the problem is being tackled gives ground for the belief that the wooden vessels will yet play a most important part in the war of starvation now being waged, and their advent will certainly add one more to the already long list of instances which the war has furnished in which the appliances and methods of years and centuries gone by have been revived and used alongside of the latest and greatest productions of modern engineering science and industry.

THE IRON AND STEEL INSTITUTE.

IN our last issue we reported the preliminary proceedings at the meeting of the Iron and Steel Institute held on Thursday, May 3, including certain alterations in the by-laws and the presentation of the Bessemer Medal.

REFRACTORIES.

Three papers were down for reading, but the interest aroused by Mr. Cosmo Johns' paper on the "Properties of the Refractory Materials used in the Iron and Steel Industry" so prolonged the discussion that the reading of the other two papers had to be postponed. In our last issue Mr. Cosmo Johns' paper was published in full, but some additional observations were made by the author before the discussion was commenced. He drew attention to the high resistance of bricks consisting of 3 per cent. of lime mixed with sand. These were moulded under pressure and were boiled, not baked. He had used these in comparison with standard silica bricks in furnaces producing alloy steels. Many had asserted that these lime bricks were useless, tumbling to pieces when heated. This happened solely because the bricks were heated too rapidly, allowing insufficient time for the formation of the silicate of lime. They must, in fact, be dehydrated very slowly. Taking this precaution, he had found that after four weeks the lime bricks stood out ½ in. beyond the standard bricks. Commenting on the schedule of refractory requirements appended to his paper, the author observed that the endurance of nozzles was largely a question of the composition of the steel and the conditions of pouring. In certain cases carbon nozzles had proved very satisfactory.

The discussion was opened by Sir Robert Hadfield, who said that the paper was of unusual value, embodying many suggestions as to matters to which due attention had not been paid in the past. How far makers of refractories were to be blamed for recent troubles it was difficult to say. The intensified rate of production for war purposes was such as to show up weaknesses previously unsuspected, and he would therefore say nothing against firebrick manufacturers. Nevertheless his firm had found that many makers were unable to give analyses of their products. Of course the endurance of refractories was not solely a matter of chemical composition, but, admitting this, it was disappointing to find so many makers who thought they could get along without help from constant analytical checks. Similarly he had found makers with no means of determining firing temperatures. The best results could not be expected under such conditions. In fact it was the positive duty of pyrometer makers to call on every firebrick manufacturer in the kingdom and insist on his purchase of a pyrometer. The council of the Faraday Society, being of opinion that insufficient attention had been paid here to the study of refractories, arranged for a symposium on the subject, which was held last November. At the outset they had thought that they would get at most two or three papers submitted to an audience of, say, 30 members. Actually however, it turned out that the subject was one of national importance, and they received nearly two dozen papers, and about 300 were present at the meeting. He suggested that it would be well if the Iron and Steel Institute circulated amongst its members the report of this symposium, which had led to the establishment of the Institute's committee. He hoped, however, that matters would go further, and that the Institute would agree to give financial support to the investigations in view. At Stoke Dr. Mellor had done magnificent work for the Ceramic Society, before which a large number of important papers had been read. He wished the Institute would collaborate with the Ceramic Society and support the researches inaugurated by it.

Professor William Bone, who spoke next, agreed as to the great importance of the subject at this juncture, and to none was this importance greater than to the Iron and Steel Institute, which was, moreover, particularly well fitted for working out the problems involved. In England we had not given nearly as much attention to research on refractories as we ought to have done. Some ten years ago he had been much struck with the attention paid to the investigation of materials used for coke ovens in Westphalia. He could not help comparing the character and extent of the researches there in progress with the absence in this country of anything equivalent thereto. He had often felt that the work there being done showed a prescience which we might well have emulated. Similarly, when he visited America some two or three years later he saw what extensive researches on refractories were there in progress. Indeed, in connection with the special process of combustion in which he was interested, he had received much more help from American investigations than from almost any other quarter. He realised that the possibilities of the process in question might be limited by the problem of finding suitable refractories, and had formed the conviction that the subject provided one of the most important fields of research still to be taken up. Amongst the few good things brought about by the war the recognition of the importance of this problem was one of those with the greatest potentialities. At the Imperial College Mr. Hancock had undertaken a research on coke-oven linings and firebrick. This was being pushed on as fast as their resources in materials, equipment and men would allow. The enormous variety of the problems involved was such as to be beyond the powers of any single institution or man to cope with. The aid of all competent workers and of all well-equipped laboratories must be enlisted and organised. He hoped that any committee formed would ascertain what the present facilities for such researches were and who were qualified to undertake the work. A considerable expenditure must be faced, and in view of the fact that the iron and steel trade was valued at 100,000,000*l.* per annum, he held that provision for the proposed investigations should be largely derived from these industries. He would plead with large manufacturers who used these materials daily, and whose success in the future would depend largely on the advances made, to give liberal financial support. He would further suggest that in forming committees the workers must not be left out. He was not in love with research committees, though they were useful to establish co-ordination and co-operation, but they were seldom fruitful in original ideas. They should therefore be fairly large, and include in their organisation the workers themselves, stimulating them by arranging for informal and unreported discussions in which ideas might be exchanged. Some of the problems were hardly yet in a position to be taken up. The only criticism he would make of Mr. Cosmo Johns' paper was the suggestion that the thermal conductivity of refractories could be easily measured. He did not think that it would be at all easy. Some years ago he had to try to determine the rise in the thermal conductivity of certain refractories as the temperature rose from 500 deg. to 900 deg. C. Although he had a well-equipped laboratory, he had found the investigation unusually difficult in spite of the relatively low maximum temperature attained. He thought, therefore, that at temperatures of over 1,000 deg. C. the measurement would be one of extraordinary experimental difficulty. Indeed, it would be well not to assume that any of their problems were going to be easy. The whole of our available skill would be required, and many researches would, moreover, take a long time to complete. He observed that the gas industry had appointed a committee to improve and standardise the quality of retorts. The result had been very satisfactory, and he suggested that work on similar lines might prove advantageous to the steel industry.

Mr. Dennehy said that as a manufacturer he would welcome a closer connection with the steel makers, but he thought that he might say without unfairness that when a firebrick maker tried to introduce something new and better he met with remarkably little support from the steel men.

Professor Arnold said that the author had exceptional qualifications for the task he had undertaken in preparing his paper. He was at once a geologist and head metallurgist of the Siemens department of Vickers' works at Sheffield. The speaker's own researches on refractories, made some twelve years ago, had led to far from pleasant consequences. When he was erecting a 2½-ton Siemens furnace at the college he was advised not to use Yorkshire silica bricks, which were asserted to be "not in it" when compared with German makes. To test the matter two square feet of the furnace were lined with the latter, and after but 10 heats their superiority was most manifest, as they stood out fully two inches beyond the surface lined with the Yorkshire bricks. He had sent for the maker of the latter and had had a very hot hour with him. He gave him full data, including the analyses of the German bricks, which contained only 92 per cent. of silica. At this his conferee declared that he would be ashamed to put such stuff on the market. The speaker had then asked what was the use of a remark of that kind in view of the actual results. The matter was taken up by the press and he was severely attacked, but he told the local makers squarely that until they could supply goods of equal quality every one of his furnaces would be lined with the German bricks. For 18 months this was done, and then two British makers challenged a comparative test. The speaker accordingly lined

his Siemens furnace for one-third of its area with the German bricks and the remainder with the products of the challengers. The test was a very severe one, and all three gave equal results. He had pointed out at the time that chemical composition was not decisive of quality. The grading of the German bricks was different from the inferior local brick, and from a chemical standpoint it was extremely impure. It was, however, far finer in texture, and hence, though chemically inferior, it was infinitely superior in the furnace. So far as research on refractories went he could say that at Sheffield they had not been asleep. They had a big scheme in hand which would cost 30,000*l.* for equipment, of which half had been raised locally and the remainder provided by the Treasury, and there would be an annual expenditure on the work of 3,000*l.* In this connection he might add that having mentioned to Sir Robert Hadfield that they were still 2,000*l.* short of their half-share of equipment cost, he received from him next morning a cheque for the balance needed. In this scheme of research the study of refractories would form one of the main features. In conclusion he would like to add a word of caution with reference to the nonsense about refractories published in text-books. At time, he was amused at this and at others angry. Quite recently he had found in one the statement that silica melted at under 1500 deg. C. If this were so, how would it be possible to tap steel at over 1600 deg. C. through silica gates. No doubt silica would soften at 1,450 deg., but the statement that this was its melting temperature showed the ignorance of the author.

Mr. Ridge said that he could state from experience that our clays were not inferior to the German, but they were not used to the best advantage. The Germans treated even their best clay scientifically, and were at the same time able to get good products from inferior clays. Scherin had found that it was easy to eliminate ordinary impurities from raw clays and on a commercial scale. Just before the outbreak of the war steps were, in fact, being taken to establish the process in this country, and he thought that the foundation laid by Scherin should be followed up. In particular, alkalies could be eliminated almost entirely, a point of great importance in view of their fluxing effects. At Briesen, in Austria, there was a deposit of a very remarkable clay. In itself it was not very plastic, but added to the extent of 5 per cent. or 10 per cent. to fireclays the effect on the quality of the refractories and firebricks made was remarkable. It was used for coke ovens, retort linings and similar purposes, generally in the proportion of 10 per cent. It contains some 38 per cent. of alumina, and could not, therefore, be adopted for silica bricks, but added to fireclay bricks, it greatly increased their resistance to softening and to the action of molten metals and slags. Bohemian kaolin was also used extensively in the best German firebrick works. In the pure state it would withstand temperatures up to Seger cone No. 36, and its addition had gone far to improve the quality of the firebricks made. Much attention had been paid in Germany to determining the amount of "grog" that could enter into the composition, and also the best size of the particles. Germany had within its own boundaries quite an insufficient supply of good "grog" which would not shrink in the furnace, and had therefore to import shale from Scandinavia. He had found that this imported shale went as far from the seaboard as the middle Rhine, and was also used in Silesia, although it had in that case to be carried some 80 miles by rail. As for our own firebricks, he had found great difficulty in obtaining a continuous supply of properly burnt products. Recently, where a number of new furnaces were being erected he had examined one not long started-up and found serious shrinkage. He next examined the bricks that were to be used for additional furnaces, and of these a large percentage (all from well-known makers) proved to be very imperfectly burnt, and were therefore certain to shrink in the furnace. This difficulty could be overcome by careful supervision. The user must, however, also exercise care. It was not reasonable treatment to carry firebricks in open railway trucks, or to store them in the open after delivery, and then heat them up quickly in the furnace. German makers were prepared to specify the analysis of their bricks, stating upper and lower limits for the different constituents, and also to quote the Seger cone number at which they would begin to soften. If our own makers would act similarly it would be a great benefit to the metal industries. For this to be practicable, however, a replica of the Charlottenburg testing plant would be necessary. He had not been able to find anywhere in this country a place where even a single brick could be tested. At the most he was told at one meeting that pieces $\frac{3}{8}$ in. in diameter by 2 in. long could be dealt with. There was a difficulty in providing such specimens, and the results recorded were not always the same as with a whole brick. It would be of great value if the Institute could arrange for a testing plant where even single bricks could be dealt with. The author had noted that in some cases the insulating properties of bricks were important and in other cases their conductivity. In practice we had to use the same brick for both purposes. With retorts his experience had been that the results depended less on the materials used than on the way in which they were treated in the process of manufacture. Hand-made retorts were more porous than hydraulically-pressed ones which, in consequence, resisted better the action of gases, slags and mattes. Thus resistance to corrosion or erosion might be enhanced by greater care in manufacture, without alteration of the materials used.

Professor Arnold, speaking again, said in reply to Mr. Ridge that whole bricks could be tested at Sheffield, in either their 2½-ton Siemens furnace, where temperatures of 1750 deg. were reached, or in their crucible furnace, giving temperatures up to 1650 deg. C.

Mr. Saniter, who followed, said that he was impressed most with the need of co-operation with other societies. He did not know all the names in the the Institute's committee, but did not notice any firebrick makers, whom it was essential to draw into the matter. As to the author's schedule, he noticed that magnesite was put down as used for electric furnaces. Of course it was also used for basic Siemens furnaces. The magnesia bricks made in this country were very inferior. His own experience was that an iron bond gave the best results. Bricks containing 7 per cent. to 8 per cent. of this bond were much more satisfactory than the bricks usually supplied, and did not deteriorate nearly so rapidly. A high percentage of magnesia was unnecessary,. better results being obtained with less magnesia, and a better bond. The question of spalling under changes of temperature was being studied by Dr. Mellor. He might add that the sands used for the bottoms of open-hearth furnaces were now all English, and stood better than the Belgian previously used. This arose from a failure to "let down" the Belgian sand sufficiently before use. There was no difficulty in making dolomite bricks, but they would not keep for more than six weeks, after which they began to collapse again. In fact tarred dolomite bricks, agglomerated by pressure, must be used immediately. There was some deterioration in the silica bricks now available, but on the whole manufacturers had done well. The question as to how much lime should be used required investigation. He had found that sand bricks agglomerated with 4 per cent. of lime stood up well, and ganister jointings having 92 per cent. of silica bonded with lime wore away evenly with the brick linings in spite of the large percentage of flux.

Professor Thomas Turner said that on the Continent and in America the study of refractories had been developed much more than here, but present necessities had excited a wave of interest, which he trusted would not be prove to be merely temporary. A lot of pioneering work would be necessary. The question should be attacked both from the research end and the manufacturers' end. The former would require the collaboration of them all. Many of the investigations would take a long time and require accurate apparatus, and we had institutions at our colleges and universities at which this work could be done. More, however, was required. The ordinary manufacturer was simply appalled when he heard of the kinds of test to which his materials were to be subjected. In his own district there were about 100 makers of refractories. Of these at least one-half had no system of testing whatever. Throughout the country generally there was in use no system of expressing the qualities of materials quantitatively. They were classed merely as good or bad—refractory or fusible. In steel-making simple tests, requiring, say, half an hour to complete, had been introduced, by which the quality of the product was checked in the making. Similar simple tests, capable of application by the unskilled, and not taking more than a day to complete, were needed for refractories. A number were, in fact, available for such properties as porosity, plasticity, shrinkage and tenacity, whilst the Seger cone would give the softening point. It should not be difficult for small manufacturers to obtain young men from college, at moderate pay, who would be capable of conducting such tests. By thus starting on a small scale with simple tests, a proper laboratory might ultimately be built up, whilst the suggestion of employing at the outset a highly skilled man with an expensive laboratory would have no success. So many of the firms were working on so small a scale that science must be introduced into them from the bottom. It would be absurd for such firms to have their own chemist, and analyses should be put out, but other tests should be made day in and day out and used to control the product.

Dr. Walter Rosenhain said that he thought it only fair to say a word on behalf of the National Physical Laboratory. Mr. Ridge had stated that in this country there were no establishments at which a whole brick could be melted. The speaker did not consider this necessary. For whole bricks the kind of test to which Professor Arnold had referred, in which one face was exposed to the heat, was sounder. At the National Physical Laboratory they were making tests as to the temperatures at which collapse took place at different pressures, and of the pressures which would cause collapse at different temperatures. It was true that the specimen had to be cut from the bricks, but this was not a serious matter. At Teddington, moreover, much was being done on the vital work of testing and standardising pyrometers. Tests on refractories were also in progress, though they were hampered by an insufficiency of equipment, which they hoped to make good shortly. The special group of refractories in the author's schedule was that which appealed most to the speaker. It was quite true that they were not yet in use on a large scale, but he would enter a strong plea that their efforts should not be limited to "established" materials, but regard had to the future. History showed a steady progress towards higher and higher temperatures. Electric smelting, for instance, involved the use of temperatures much higher than had previously been used in practice. The whole secret of progress might possibly lie in the securing of better refractories, capable of withstanding higher temperatures.

Mr. Hancock, who spoke next, expressed his gratification that refractories were now receiving the attention they deserved. He thought, in common justice to workers in this extensive field, that it should be stated that the study did not date from August, 1914. Much had been done years ago in Germany and in the United States. In this country the idea had prevailed that quality was settled solely by chemical analysis, but experience had demonstrated the fallacy of this view, and showed that it was the physical properties which determined the value in actual practice. Much work on English clays was embodied in the records of the Geological Society, and the work of Harker at Teddington and of Mellor at Stoke should be borne in mind. He was himself studying at Professor Bone's laboratory the texture of refractories for coke ovens. It was perfectly easy to get the texture of the raw and unfired materials, but what was wanted was a knowledge of the structure when ready for use. No method of disintegration was possible, as it destroyed the structure. The only plan admissible was to examine thin sections, as in petrography, or polished surfaces, as in metallurgy. The importance of texture was very great, as it influenced the resistance to chemical action and temperature as well as the porosity and

permeability of the material. Another matter was the resistance to abrasion. One specification proposed to test this in a kind of ball mill, but in such a test the resistance measured would be that to a series of impacts and not to abrasion. At the Imperial College they had adopted the plan of working one plate of the material to and fro over another. The test could be carried out inside the furnace itself. The experiments were not yet sufficiently complete to afford a safe basis for general conclusions, but they indicated that the abrasion was less the finer the grain and the lower the temperature. He fully agreed with Dr. Bone as to the difficulty of measuring conductivities at working temperatures. As instancing the necessity of co-ordination and co-operation, he mentioned that the examination at the Imperial College of Science of 25 test pieces for porosity and shrinkage, as affected by the proportion of "grog" to clay, had already involved 2,500 observations.

In replying to the discussion Mr. Cosmo Johns said that he had particularly wished for a discussion of his schedule. As matters stood he would have to send it out as it was. A large number of those present had had failures, and he wished they would let him have particulars of these.

Members again assembled on Friday, the 4th instant, at 10 o'clock, the president, Sir William Beardmore, occupying the chair.

Carnegie Research Fund Awards.

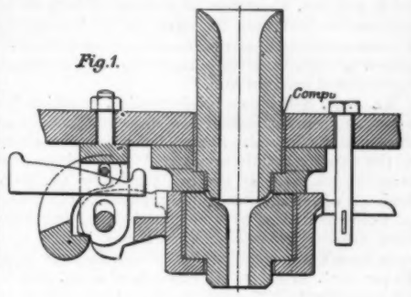
The awards made by the council from the above fund were announced to be the following:—

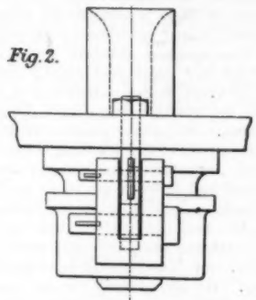
W. C. Hancock, 50*l.*, to enable him to continue his investigations on refractory materials, with special reference to the manufacture of coke-oven bricks. (Mr. Hancock received 100*l.* in 1916 to assist him in carrying out the research.) J. L. Haughton and D. Hanson, 100*l.*, to enable them to continue their joint research on iron-phosphorus and iron-carbon-phosphorus steels. (Applicants received 100*l.* in 1916 in aid of the research.) J. E. Hurst, 100*l.* for an investigation on the wearing and the microstructure of worn cast-iron specimens. J. H. Whiteley and A. F. Hallimond, 100*l.* for a joint research on the chemical detection of strain in iron and steel.

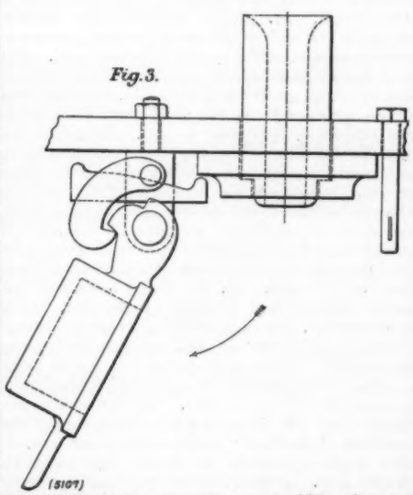
Steel Ingot Defects.

The first paper taken was one bearing the above title, by Mr. J. N. Kilby, of Sheffield. This paper we published in full in our last issue. Subsequent to the reading of the paper Mr. Kilby exhibited the Batty nozzle, which we illustrate in Figs. 1, 2 and 3, annexed. This was, he said, bolted to the bottom of the ladle. As shown, there are two nozzles in series: the lower one can be replaced during pouring, the operation requiring only a few seconds. The first nozzle may be of any size, up, say, to 2 in. With this arrangement the pouring time of a heat of top-poured 15-cwt. ingots, which would ordinarily occupy only about 20 to 40 seconds, had been extended to about two minutes. The first, or ordinary, nozzle would have a 1⅛-in. or 1¼-in. orifice, while the one below would have an opening of ¼ in. or ⅜ in. It was secured in place by a cotter, and, when desired, this cotter could be knocked out, the lower nozzle then coming away clear of the upper one. The operation involved no danger.

Mr. J. E. Fletcher opened the discussion and referred to the charts shown in Figs. 5 to 8 of the author's paper (see page 437 of our last issue). In the light of modern knowledge of slags these charts afforded much information, and might, he thought, be modified to show the increase of silicon as the steel-refining operation proceeded. The slag question was, of course, of great importance in connection also with puddling. The addition of lime to slag, while giving an opportunity for reducing the FeO in the slag, added to the percentage of silica present in the latter. Generally the temperature of formation of slag in the acid open-hearth process was in the neighbourhood of 1100 deg. C., in which case the slag corresponded roughly to the compound $RO, 2SiO_2$, which corresponded to the lowest point of the equilibrium diagram. On the one side of this point the character of the slags approached that formed in the puddling process, with a high percentage of FeO and lower percentage of SiO_2. On the other side, with increasing silicon percentages, there would be a rise of the softening temperature, until the point reached by the author's method, yielding a slag almost exactly corresponding to the composition $2RO, SiO_2$, consisting of oxide of manganese and lime, along with the slag. In the acid Siemens furnace, with increase of temperature in the presence of excess silica there would be a gradual approach to the equilibrium point, which appeared to have been reached in all the cases submitted by the author. This appeared to have a great deal to do with the "killing" of steel, and with the elimination of the slag particles in the steel itself. When there was an excess of silica, in the







form of slag, higher temperatures could be obtained, which resulted in a quiet steel. Fig. 9 in the paper, showing the effect of erosion on the sides of the bath, also bore on the point, as if, in the presence of an excess of silica, the slag could only get that excess silica from the sides of the bath, then the usual erosion troubles ensued. In connection with time of teeming the Germans had for years paid greater attention to this matter and had a better knowledge of it than our own steel makers.

Dr. W. H. Hatfield, referring to the question of the slag, desired to point out that in 1902–4 he and Professor McWilliam had published two papers treating of the action of slag upon steel, the composition of both slag and steel being stated. These papers brought out the fact, since repeatedly confirmed, that assuming the slag in the acid Siemens process to consist of silicates of iron, a position of equilibrium was approached as the carbon reduced the iron and sent up the silica content in the slag; the percentage of silica in the slag rose to such a point that the silica split up and the silicon returned to the steel. He thought the author's results in relation to the addition of lime would be more valuable if data could be given of the actual chemical reactions between the slag and the steel; a lot of limestone added to slag should move the percentage point at which the silicon would return to the steel. The author contended that in ordinary carbon steels the finely-divided or emulsified solution of slag was as little desired as in the case of special steels, although not so liable to influence the ordinary physical tests. Dr. Hatfield urged that the disadvantage of slag inclusions was equal in both carbon and alloy steels. In connection with the set of figures showing the effect of various speeds of teeming upon cracking, it would be useful if Mr. Kilby could sketch out the configuration of the ingot and the nature of the defects, namely, the direction of the cracks; and, should these have varied in their relation to the shape of the ingot, an indication of the variation would be also useful. Dr. Hatfield would substitute "included" for the word "occluded," used by the author.

Mr. A. H. Saniter was interested in the Batty type of nozzle to which Mr. Kilby had referred, and hoped more would be heard of it. He was surprised, after Mr. Kilby's strictures, to observe in the paper an illustration of a casting with the big end down. Referring to Mr. Fletcher's remarks, he would urge that not all defects in ingots were due to casting; injuries might quite well be done to an ingot by the forge people when heating it up; indeed, it was quite easy to crack or burn an ingot in that way.

Mr. C. H. Ridsdale remarked that as soon as lime was added to a charge, oxide of manganese and oxide of iron were thrown out from the slag into the metal, a fact abundantly corroborated in processes other than that of the acid open-hearth. This effect was particularly noticeable in the case of manganese, and was equivalent to adding manganese to the metal. As to pyrometry, in which great advances had been made, it was desirable that practice should be cut and dried, within narrow limits; nevertheless the difficulties of application seemed almost insuperable; and a charge in the ladle must be cast, be the temperature right or wrong. The phrase "best casting temperature" was easier to use than to define. No doubt for a given steel there was a best casting temperature from the steel point of view, but that did not necessarily agree with the best casting temperature according to shop conditions. Other considerations, such as the size of the ingot, type of nozzle, and the personal element, influenced teeming.

Mr. E. Adamson regarded the compositions of the slags as indications of temperature, and the temperature of the slag did not necessarily mean that that temperature was the same as that of the metal. A greater correlation between the composition of the slags and temperatures was needed. His experience with molten steel convinced him that the temperature of the steel, more than anything else, affected the mechanical condition of the material afterwards. He did not think matters would advance much until it was practicable to measure the temperature of the molten metal, both in the furnace and ladle, by means of pyrometers.

Mr. W. J. Foster, speaking as a blast-furnace manager, was interested in the casting temperature question. He thought too much stress had been laid, in the course of discussion, upon the relation of cracks in ingots to the fluxing material. Experiments with cast-iron, which he had conducted during the past two years or more, with a view to using it for shells, had shown him that in order to obtain a casting with low total carbon, solid, and free from cracks, he had to get a large chill (disregarding speed of pouring and temperature of the metal); in other words, he made his chill heavier in proportion to the amount of metal dealt with, cooling down quickly. He was confident, therefore, that if the moulds were made heavier in proportion to the amount of steel, sounder castings would result. The question seemed rather a physical than a chemical one.

Mr. T. M. Service thought it possible so to control

the temperature of the charge in the furnace that the casting temperature should be correct. He wondered, in view of the trouble with inclusions, why no attempt was made to take the temperature of the steel at the point where inclusions would occur. He felt that more correct results would be achieved by judging and controlling the temperature of the steel in the furnace.

Dr. C. H. Desch considered that a thorough investigation of the open-hearth slags was a piece of scientific work urgently needed. After touching on Dr. Hatfield's remarks as to the chemical composition of the slag, the speaker observed that other properties of the slag were of importance in addition to its chemical composition. The rate at which the slag could eliminate itself from the bath depended only indirectly on the chemical composition, but directly on the physical properties, such as viscosity, surface tension and specific gravity. Adding lime to a slag, in such a way as to replace ferrous oxide by lime, reduced the specific gravity, and to that extent should favour elimination. But as to the effect of the lime on the surface tension much less was known. The speaker was uncertain whether Mr. Kilby assumed that oxide of iron dissolved in the steel bath, and so acted upon the furnace bottom. He believed, however, that the work done all went to show the practical insolubility of oxide of iron in molten iron or steel; any oxide then would be in a state of mechanical suspension. But oxide of iron or magnetite was highly soluble in a molten ferro-silicate, and therefore the ferro-silicate, taking up more oxygen, might form a highly oxidising liquid material, which would be dispersed throughout the bath. Elimination was dependent more on the physical than chemical composition; it was a colloid problem, there being a colloid suspension in the steel of globules of oxide in a silicate solution. Mr. Kilby had suggested that slag inclusions were not of so much importance in the case of ordinary carbon steel; on this point the speaker, having lately examined a large number of fractures of small machine parts, had come to the conclusion that slag inclusions, however minute, were always bad. Fractures in small machine parts were in most cases traceable to the presence of slag particles.

Dr. F. Rogers suggested, in relation to the condition of the bath, that the four principal matters for consideration were: (1) The temperature, (2) the percentage of oxygen present—essentially different in the slag and in the metal, (3) the composition of the metal at the moment and of the slag at the moment, and (4) the chemical composition of the slag, apart from what might be definitely produced by the first three conditions—in particular as affected by any addition of old slag and any material coming from the charge, such as scale, sand, and so on. With regard to temperature, there were many little practical details, familiar to any efficient furnace manager, which indicated the temperature of the bath sufficiently for working purposes and enabled the melting of a charge to be carried out properly. He had found pyrometers ineffective, although he had himself endeavoured to invent one which should be suitable. He, however, did not consider that there was any excuse for having a difference of temperature between the slag and the metal in the acid Siemens furnace. It was easy to put in a charge and churn it up; if the action was tolerably good there would practically be uniformity. With all the charge in a molten state the rate of diffusion would, in the natural course of things, be very rapid, and that alone should keep the greater part of the metal at the same temperature, within a few degrees, as the slag. As to the condition of the bath, he rather opposed the addition of old slag to the charge, although this was dependent on actual conditions, such as variability of the materials used. Generally speaking, he objected also to the use of lime with the charge. If lime were not required all the way, after the charge had been boiled down with ore, he would add the lime a considerable time after the addition of ore had been stopped. Adding lime freed the iron oxide to react with the carbon in the bath. The total iron oxide in the whole system was then less, a point overlooked by everyone dealing with the subject. The total iron oxide in the furnace was minimised after the lime had dissolved in the slag. With regard to temperature, the iron oxide was also minimised in the whole system by increase of temperature. This might sound paradoxical, because an opposite action was going on, since the rise of temperature promoted oxidation of the slag. Yet from the equilibrium standpoint the net result was a decrease in the FeO. There was only one other point to which he wished to refer, viz., inclusions in ingots. His experience showed that the great majority of such inclusions could be traced to fluxed bricks, the fluxed runner brick being the chief sinner. It must be remembered that the runner brick was porous. As the air became heated and the brick got hot, there was a cushion of hot air in intimate contact with the steel flowing through it, accompanied with physical and mechanical difficulties in connection with the latter, and resultant formation of oxide of iron.

Mr. J. N. Kilby then briefly replied, reserving for a written communication his answers to many of the questions raised. Some of the remarks made in the paper certainly appeared to be analogous to observations made in the two papers by Dr. Hatfield, to which the latter had referred. The point on which he desired to lay emphasis had apparently been missed. It was this, that slag in the acid open hearth was rarely shown to contain more than 50 per cent. to 53 or 54 per cent. of silica, and in his paper he had pointed out that the addition of lime gave a high percentage of silica, a fact not dealt with in any text-book or paper that he had seen. The speaker did not claim originality in respect of any particular point, although in the course of many years' experience it was generally possible for workers to suggest improvements in main ideas. Of course pioneer work on the ingot had been carried on for a long time before it was discussed; he believed, for instance, that the central-run mould had been in use some twelve years, the only novelty about it being the bringing of it forward. He had not stated that any relationship existed between chemical composition and cracks in ingots, but merely that casting influenced the cracking. He agreed that the use of a thin mould rendered cracking more likely than a proportionately thick mould. Dr. Rogers considered the addition of lime in the early stages of the melting process as a disadvantage, preferring to add lime later. But if, as he (the speaker) had stated, the adding of lime was an advantage at the later stages, when the conditions were better, it was surely an advantage to add lime from beginning to end. He might say that the addition of old slag was a compromise to meet working conditions, which could not be chosen at will. With reference to slag particles and the effect of limestone, the speaker referred to work he had done in connection with the manufacture of special steels for high-quality wire, work which gave good grounds for his opinion of the effect of limestone on the steel. Dr. Desch had mentioned the specific gravity and viscosity of the slag. As a matter of fact, in a slag containing a high percentage of lime, which, as he had said, was apparently more mobile, the elimination of carbon was not so great or erratic as in the case of a slag which was lower in silica but poured thicker. The latter was not reliable, and did not give a true indication of the condition of the bath; a slag with 50 per cent. of silica might apparently be thicker than one with 60 per cent. of silica where the lime condition varied.

QUENCHING EXPERIMENTS.

Two papers, one entitled "Notes on Some Quenching Experiments," by Mr. Lawford H. Fry, of Burnham, Pa., U.S.A., and the other "The Penetration of the Hardening Effect in Chromium and Copper Steels," by Mr. L. Grenet, of Firminy, were next read by the secretary, and were discussed together. In Mr. Fry's paper the results of an extensive research into the effect of form and rate of cooling on the heat treatment of steels was recorded. The resultant physical properties were determined, the author stated, not by the rate at which heat was lost per unit of surface, but by the rate at which it was lost per unit of weight. Hence, in discussing the heat treatment of steel, it was necessary to define not only the cooling medium, but the size of the piece cooled. "Water quenching" and "air cooling" are accordingly very indefinite terms, the essential factor being the rate at which fell the temperature of the body under treatment. Mr. Grenet's paper was in the main the report of an investigation made to determine how far copper could replace nickel in chromium steels. The author notes that the rate of cooling necessary to secure the hardening of special steels is lower than is required with ordinary carbon steels, and his experiments consisted in the main in making Brinell hardness tests of the surfaces of specimens of different composition and heat treated in different ways. He concludes that copper increases the depth to which the hardness penetrates, particularly in the case of chromium steels. Alloy steels containing copper-nickel and chromium are, he finds, "semi-hard." They can be hardened in fairly large sizes by air cooling, but can also, like carbon steels, be softened by annealing.

Dr. J. O. Arnold, who opened the discussion, said that M. Grenet had omitted, in his paper, to consider two primal questions in connection with the action of copper and nickel on pure iron. In the steels mentioned only the chromium was acting with the carbon; there was no carbon with the nickel or the copper. In round numbers—taking pure iron, or steel with only 0.17 per cent. of carbon—the addition of 7 per cent. of nickel or of 28 per cent. of nickel gave practically the same mechanical test, *i.e.*, 28 tons. With the addition of 14 per cent. of nickel the stress went up to 90 tons, with a 45 per cent. reduction of area. There would therefore, at that point, be either a saturated solution of nickel in iron or a nickelide of iron, Fe_6Ni, corresponding to the percentage given. Really, in these steels the nickel was associated only with the iron and not with the carbon at all. In 1894 the speaker had read a paper before the Institute on the influence of elements on iron, the case of copper proving somewhat astonishing. The addition of 2 per cent. of copper to nearly pure iron raised the maximum stress of the latter from 21 tons to 34 tons per square inch, and also raised the elastic limit from 11 or 12 to 30 tons. Judging from work he had since done, the copper seemed to dissolve pretty readily in the iron up to 2 per cent. Experiments he had made in the direction of welding two pieces of very mild steel with copper showed that the copper weld was the strongest part of the metal. A thin strip of electrolytic copper was placed between the two plates of steel, clamped together, and the whole put into a crucible and covered with coke dust, moistened with a solution of sugar, so as to obtain a CO atmosphere. Taking the pieces of steel up to a temperature of 1100 deg. for two or three hours, the film of copper between the plates dissolved completely in the steel. Assuming a dead mild steel and a copper weld of 2 per cent., the strength at the copper weld would be stronger by several tons than at any other part of the steel. The copper, as such, disappeared, and all that could be observed of it under the microscope was a slight blueing on polishing, representing the solid solution of the copper in the mild steel. It seemed to the speaker that the question of the hardening influences of the copper and nickel on the iron presented a very complex problem independently altogether of the carbon.

Dr. Hatfield merely observed, in reference to Mr. Grenet's paper, that he presumed the author had endeavoured to see how far copper could replace nickel. The work was very creditable, and would save many other metallurgists from going over the same ground.

Dr. Desch, criticising Mr. Grenet's paper, remarked that in the absence of microphotographs there was no evidence that what had been measured was the actual penetration of the hardness. The hardness of a case-hardened surface depended on two factors, namely, the rate of combination of carbon with the iron or other element present and the rate of diffusion inwards. With a rapid rate of combination and formation of a large quantity of carbide at the surface, the surface would be hard although the penetration might be small. On the other hand, the rate at which carbide diffused into the metal would be much affected by the presence of solid solutions, such as those referred to by Dr. Arnold. He would scarcely have expected that the presence of carbide in solid solution would favour

the diffusion of the carbide inwards; in the case of a solid solution containing copper he would think that the carbide would diffuse less readily than in pure iron. The case of chromium and nickel was different, because of the possibility of carbides forming in solution. It would therefore be interesting to know whether microscopic investigation would confirm the statement that there was greater depth of penetration in the case of copper. The speaker considered Mr. Fry's paper of much service in directing attention to the need for accurate specification when the properties of heat-treated metals were being discussed; for instance, a statement of the size of the object from which a test piece has been taken.

Dr. W. A. Bone expressed a doubt whether Mr. Fry had succeeded in accurately determining the mean temperature of his specimens.

The remaining papers were taken as read, and votes of thanks having been accorded to the Institution of Civil Engineers for the use of their building, and to Sir William Beardmore for his conduct in the chair, the proceedings were closed.

CEMENTATION BY GAS UNDER PRESSURE.*

By F. C. LANGENBERG (Harvard University).

Introduction.—With the exception of the brilliant work of Giolitti, very little has been done on the subject of cementation or decarburisation under pressure. The work by Giolitti is too well known to require discussion. In his work a furnace was employed which had several defects, namely, the inability to maintain a constant temperature, probably due to the lack of any cooling provision for the jacket, and the inaccessibility of the interior.

The author of this paper feels that a description of the pressure furnace which has been developed in the Physical Laboratory of Harvard University, developed a furnace which, in the author's opinion, could be made useful for cementation work under pressure if properly modified. Through the kindness of Dr. Hayes it was possible to undertake the construction of a furnace similar to the one used by him, and the one herein described is a modified form of that furnace. The essential features are similar, but such improvements have been made as were necessary to make the apparatus suitable for metallurgical experiments.

Financial conditions made it necessary to cut down the dimensions of the proposed unit as originally planned and shown in the accompanying sketch (Fig. 1), but the proportions were not disturbed nor was the usefulness of the apparatus seriously impaired. The attempt has been made in the construction of the furnace to combine all the requirements of a vacuum and pressure furnace into a single unit, and at the same time to do so as economically as possible. A short description will give an idea of the furnace proper.

The heating unit consists of an alundum tube, threaded on the outside, nine turns to the inch. On this tube is wound No. 16 nichrome wire, which gives a total coil resistance of 10 ohms.

A mixture of alundum cement and water was then prepared, which was firmly pressed on over the wire, to a thickness equal to that of the tube itself. This was dried and then baked at a high temperature for several hours. An asbestos steam pipe cover of the proper length was then reamed out so as to fit very closely over the cemented tube. Finally a layer of asbestos felt was wrapped tightly over the pipe cover. In the section, Fig. 1 (starting from the inside and moving outward), can be seen (1) the alundum tube threaded to receive winding, (2) layer of alundum cement, (3) asbestos pipe cover, (4) asbestos felt.

The heating unit was assembled as follows:—Cast-iron end-plates were made which have two circular projections on their inner surface. The ends are held in place by four tie-rods, none of which appears in the section. As can be noticed in Fig. 1, the alundum tube fits into the first projection, and the outside flange fits snugly over the outer layers of asbestos felt. The terminals of the nichrome winding are brought out to two binding posts, which are insulated from the cast-iron head by mica tubes and washers. This method of assembling gives a very strong and convenient heating unit for any jacket is 1 in. in thickness and consists of a cylinder with flanges at the ends to which are bolted the heads. The joint between heads and cylinder is secured by a suitable gasket. Fig. 1 shows copper gaskets ¼ in. thick, but it was found later that a better fit could be maintained by the use of an asbestos-graphite gasket $\frac{1}{16}$ in. in thickness. All bolts are ½ in. in diameter, standard thread.

The heads, front and back, are shown in section, Fig. 1. The rear head was tapped and threaded for spark plugs, through which current is carried to supply the heating unit. This device has proved simple and effective. Spark plugs were chosen with strong central leads and connections made internally to the binding posts of the furnace and externally to the supply circuit. There is no danger of the furnace grounding on the jacket, and the plugs insure gas-tight, electrically insulated connections.

The rear head was also tapped and threaded for ⅛-in. double-thick pipe, through which connections can be made to the pressure and vacuum pumps. The rear head was also tapped and threaded to receive a pipe in which the thermocouple is inserted. This pipe is shown in position in Fig. 1. It had a very serious drawback in that the furnace had to be completely torn down for the insertion of a new pipe. This was overcome by a very simple device. A steel plug was turned from 2-in. stock and provided with 1-in. standard thread. The plug was then tapped and threaded to receive the pipe which was to hold the thermocouple. The hole in the head was then enlarged to receive the plug carrying the pipe. It was then a very simple operation to remove this plug and insert a new pipe without disturbing the furnace in the least.

The front head of the furnace was cast from the same pattern as the rear one. The arrangement of the conical plug which forms the working door of the furnace is shown in section in Fig. 1. The plug was cast and turned down to a good machining fit, after which it was ground to an accurate fit by first using emery, then tripoli powder, and finally jewellers' rouge. The plug fits so securely in its seat that some device is necessary to remove it. The three-bolt system shown in section in Fig. 1 was not successful. It consisted of three bolts, one screwed into the plug, and two others screwing into the furnace jacket, all provided with two nuts, one above and one below the strap. When one desires to remove the plug the two top nuts on the bolts fastened to the jacket are unscrewed, and then by unscrewing the two under nuts on the same bolts outward pressure is exerted on the strap, which in turn is transmitted to the plug by the centre bolt. When operating under vacuum the plug does not have to be held in place, as the external air pressure is sufficient. When operating under pressure the plug is held in position by tightening the outside nuts on the bolts in the jacket. As stated previously, this means of removing the plug was not satisfactory, for the obvious reason that no twist could be exerted on the plug. To overcome this a new plug strap was made which was considerably longer. The extremities of the strap were tapped and threaded for 2½-in. set-screws of sufficient length to bear on the jacket head. To remove the plug all that is necessary is to loosen the two outside nuts on the bolts which screw into the jacket and then tighten up the set-screws. If this does not bring out the plug the arm can be revolved, and with the set-screws well tightened a twisting pull is exerted which always removes with ease the plug from its seat. Circulation under pressure inside the jacket is provided for by inserting a pipe into the conical plug fitted with two valves. Two valves were used, as it gave a more delicate control of the amount of gas passing from the furnace when operating under high pressures.

The cooling of the jacket is accomplished by the thermo-siphon system of oil circulation. The cooling jacket was made by two cast heads (shown in section, Fig. 1) and a section of steel pipe of the proper length and diameter, assembled by tie-rods and the necessary gaskets. Rubber gaskets have been used with perfect satisfaction, and no difficulty is experienced in making tight joints. The inlet is at the bottom and the outlet at the top, connection being made to a galvanised iron tank, used as a radiator and oil reservoir. A drainage tap is provided at the bottom for removing the oil when necessary.

The installation for pressure work consists of the following appliances: motor, compressor, storage tank, pressure gauge, and the necessary valves. The motor is a Holtzer Cabot, ½ h.p. at 1,200 revolutions. It is belted to a short line shaft, to which in turn are belted the vaucum pump and compressor. The compressor was made by H. G. Crane, of Brookline, Mass., and consists of two cylinders, air-cooled, operating at 500 strokes per minute. The clearance has been reduced to a minimum, and high pressures can easily be reached in a short time. The exhaust from the compressor is piped to a storage tank (in cabinet under bench), and from the tank to the inlet in the furnace provided for pressure. Valves were inserted in the line between the furnace and gauge, between gauge and tank, and between tank and

Fig. 1. VACUUM AND PRESSURE FURNACE.

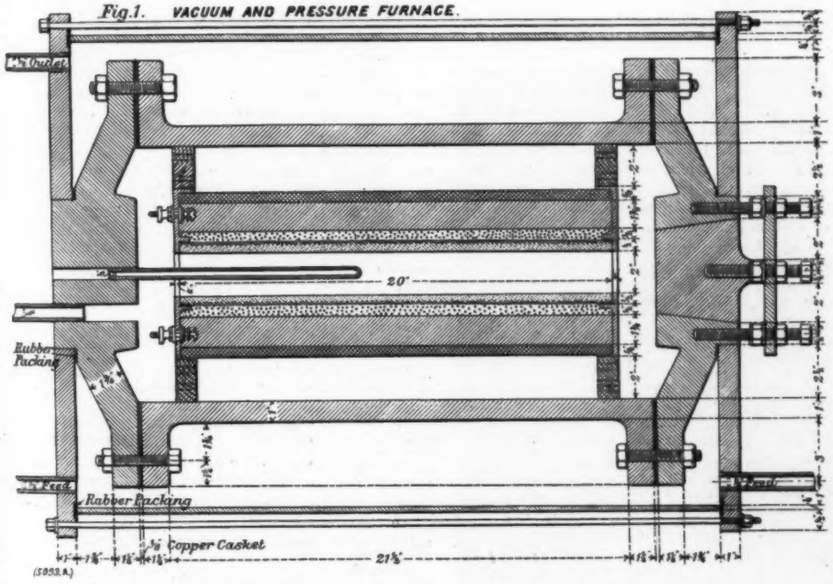
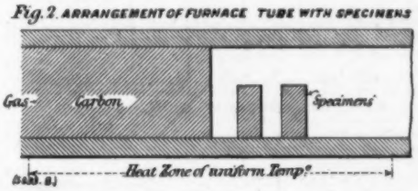


Fig. 2. ARRANGEMENT OF FURNACE TUBE WITH SPECIMENS



Harvard University Metallurgical Laboratory will be justifiable, as some of the defects encountered in the use of former furnaces have been overcome. The experimental results herein presented, it is hoped, will be of some interest in themselves. It is realised that they are far from complete, but it is hoped that additional data may be presented at a future date.

Acknowledgments.—The author wishes to express his sincere appreciation of the assistance rendered by the following gentlemen:—Professor Albert Sauveur; Professor H. L. Smyth; Professor Charles H. White; Dr. H. C. Hayes, instructor in physics, Harvard University.

The author is especially indebted to Professor Albert Sauveur for his encouragement and frequent suggestions in the course of this investigation; to Professor H. L. Smyth, whose deep interest in the subject made it possible to secure the necessary funds to carry on this work; to Professor Charles H. White for his suggestions and assistance in the analytical work necessary in this investigation; and to Dr. H. C. Hayes, for the loan of certain patterns and his many valuable suggestions in the construction of the furnace used.

Description of Apparatus.—Dr. Hayes, of the Jefferson sort of furnace work not exceeding 1100 deg. C. when used in an oxidising atmosphere.

As previously stated, the total resistance of the winding is about 10 ohms. When thrown across a 110-volt line a temperature of 1100 deg. C. is attained in 10 minutes. If so large a current be allowed to continue, the coil will soon reach a temperature which will be destructive. It has been determined that 6.6 amperes will supply energy at a rate equal to the loss by radiation at 1000 deg. C. (pressure being atmospheric). All that is necessary in the operation of such a furnace is to determine the temperature maintained by a certain energy supply. A number of such determinations similar to the one above were taken and a curve drawn between the points thus obtained. With a constant line voltage the control is very simple. In starting full load can be thrown on, and when the desired temperature is reached external resistance can be introduced to reduce the energy input to the predetermined value taken from the curve.

The utilisation of the heating unit as a vacuum or pressure furnace is accomplished by inserting it in a steel jacket (see Fig. 1). The furnace proper is supported in the jacket by two asbestos wood rings, one at each end. These supporting rings are perforated with a series of holes to allow free circulation of gases. The

* Paper taken as read before the Iron and Steel Institute, Friday, May 4, 1917.

pump. These various valves make it possible to read either the pressure in the tank or the pressure in the furnace. The pressure gauge is of the Crosby type,

Fig. 3. SERIES 5, 6, 7. RATE OF FLOW-CARBURISATION CURVES

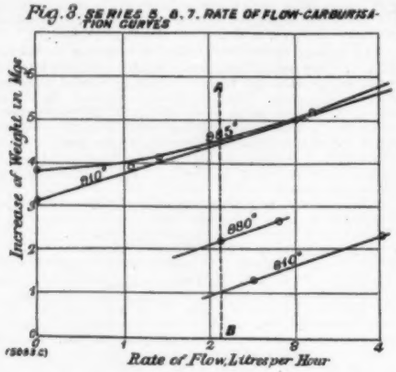


Fig. 4. TEMPERATURE-CARBURISATION CURVE. DATA DERIVED FROM PREVIOUS CURVE

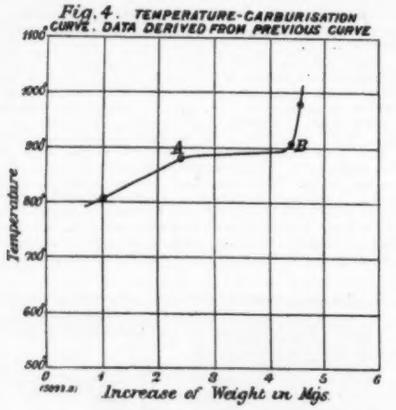


Fig. 5. SERIES 9. TEMPERATURE-CARBURISATION CURVE

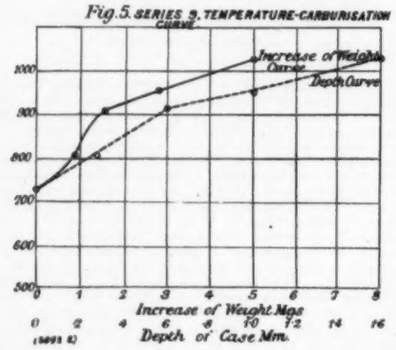
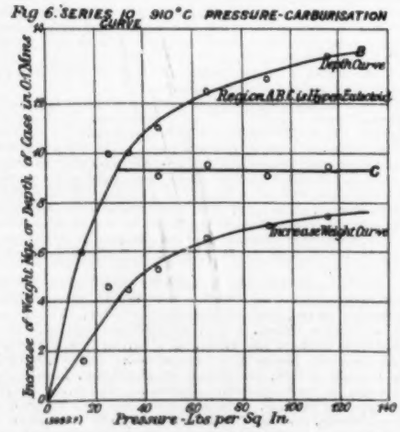


Fig 6. SERIES 10. 910°C PRESSURE-CARBURISATION CURVE.


Depth Curve
Region A B C (all Open Cutectoid)
Increase Weight Curve
Increase of Weight Mgs. or Depth of Case in 0.01 Mms
Pressure - Lbs per Sq. In.

reading in pounds, the one in use at present having a limit of 300 lb.

The vacuum pump is an oil-sealed, plunger type. It has two cylinders, 5-in. stroke by 2-in. bore, connected

TABLE I.—SERIES 1. CEMENTATION IN ILLUMINATING GAS.

Specimen.	Weight in Grammes.	Change of Weight.	Change per Sq. Cm.	Time. Hours.	Temperature.	Pressure.	Rate of Gas Flow.	Hyper. Case.	Eutectoid Case.	Hypo. Case.	Total.	Remarks.
								mm.	mm.	mm.	mm.	
S-1-3	21.0803	0.0025	0.000227	3½	1020	Atmospheric	6 litres per hour	0	0	0	0	Specimen slightly blue. No case.
S-1-4	19.7149	0.0023	0.00022	3½	1020	,,	,,	0	0	0	0	,, ,,
S-1-5	20.6930	0.0005	0.000045	5	1000	,,	2 litres per hour	0	0	0	0	Blue on side facing current. No case.
S-1-6	18.5155	−0.0001	−0.00001	5	1000	,,	,,	0	0	0	0	Very bright. No case.
S-1-7	20.5942	0.0004	0.000036	4	1010	,,	0.0 litre. No gas passed	0	0	0	0	Slightly straw-coloured. No case.
S-1-8	18.5018	0.0001	0.00001	4	1010	,,	,,	0	0	0	0	,, ,,
S-1-N-M	18.6430	0.0016	0.00016	3	1000	,,	3 litres per hour	0	0	0	0	Blued. No case.

TABLE II.—SERIES 2. CEMENTATION IN ILLUMINATING GAS.

								mm.	mm.	mm.	mm.	
S-2-1	21.7640	−0.0002	−0.000018	6	900	,,	2 litres per hour	0	0	0	0	One side was light straw. No case.
S-2-2	19.9070	−0.0001	−0.000010	6	900	,,	,,	0	0	0	0	Very bright. No case.
S-2-3	22.4146	0.0003	0.000026	5	910	,,	0.2 litre per hour	0	0	0	0	Very light blue. No case.
S-2-4	22.1366	0.0000	0.00000	5	910	,,	,,	0	0	0	0	Light straw. No case.

The results are similar to those of Series I. In no case did carburisation ensue. Carbon was deposited in the cold ends of the tube, as in the previous series.

TABLE III.—SERIES 4. CEMENTATION OF ARMCO IRON IN C_2H_2.

								mm.	mm.	mm.	mm.	
S-4-A	18.8181	0.0013	0.00013	4	1005	Atmospheric	1.44 litre per hour	0	0	0	0	Specimens dull black when removed. No trace of deposited carbon.
S-4-B	19.2017	0.0021	0.0002	3	1005	,,	2.75 litres per hour	0	0	trace	trace	,, ,,
S-4-C	19.2371	0.023	0.0023	4	1000	,,	10 litres per hour	0	0	3.5	3.5	Rear of tube choked. Specimen black. Case about 0.30 per cent. carbon.
S-4-D	19.3816	0.0578	0.0055	4	940	,,	5 litres per hour	0	0.5	1.3	1.8	Furnace choked. Specimen black. Good commercial case.

TABLE IV.—SERIES 5. CEMENTATION IN C_2H_2.

								mm.	mm.	mm.	mm.	
S-5-G	19.3739	0.0431	0.0038	4	980	Atmospheric	0.00 litre per hour	0	0	1.25	1.25	Carbon about 0.70 per cent. max. Specimen very bright.
S-5-E	19.3149	0.0431	0.0041	4	985	,,	1.4 litre per hour	0	0	1.50	1.50	Carbon about 0.70 per cent. max. Specimen very bright.
S-3-F	19.2207	0.0548	0.0052	4	985	,,	3.25 litres per hour	0	0.25	1.50	1.75	Specimen very bright.

TABLE V.—SERIES 6. CEMENTATION IN C_2H_2.

								mm.	mm.	mm.	mm.	
S-6-I	19.2594	0.0326	0.0031	4	900	Atmospheric	0	0	0	1.4	1.4	0.75 m. about 70 per cent. carbon. Specimen very bright.
S-6-J	19.0167	0.0408	0.0039	4	905	,,	1.1 litre per hour	0	0	1.4	1.4	,, ,,
S-6-K	19.2900	0.0527	0.0050	4	900	,,	3 litres	0	0.5	1.25	1.75	Specimen very bright.
S-6-H	19.2133	0.0229	0.0022	4	880	,,	2.25 litres per hour	0	0	1.1	2.1	,, ,,

TABLE VI.—SERIES 7. CEMENTATION IN C_2H_2.

								mm.	mm.	mm.	mm.	
S-7-L	19.5552	0.0265	0.0025	4	810	Atmospheric	4 litres	0	0	1	1	Specimen very bright. Case low in carbon.
S-7-M	19.3124	0.0641	0.0061	4	900	,,	1.6 litre	0	0.4	1.1	1.5	Specimen very bright.
S-7-N	19.3624	0.0646	0.0061	6	900 Uncertain	,,	0	0	0	2	2	Specimen very bright. 0.6 mm., about 0.60 per cent. carbon.
S-7-O	19.3789	0.0278	0.0027	4	880 Uncertain	,,	2.75 litres	0	0	1	1	Specimen very bright.
S-7-P	19.4602	0.0133	0.0013	4	815	,,	2.50 litres	0	0	0.8	0.8	,, ,,

TABLE VII.—SERIES 9. ILLUMINATING GAS.

								mm.	mm.	mm.	mm.	
S-9-S	19.2463	−0.0006	−0.00005	3	720	Atmospheric	5 litres per hour	0	0	0	0	Specimen very bright.
S-9-P	19.3796	0.0089	0.0009	3	810	,,	,,	0	0	0.3	0.3	,, ,,
S-9-Q	19.4453	0.0171	0.0016	3	910	,,	,,	0	0	0.6	0.6	,, ,,
S-9-O	19.3815	0.0298	0.0028	3	950	,,	,,	0	0	1.0	1.0	,, ,,
S-9-R	19.4783	0.0522	0.0050	3	1025	,,	,,	0	0.25	1.35	1.6	,, ,,

TABLE VIII.—SERIES 10. ILLUMINATING GAS.

						lb.		mm.	mm.	mm.	mm.	
S-10-F	19.3041	0.0476	0.0046	3	910	25	5 litres per hour	0	0.25	0.75	1.0	Specimen very bright.
S-10-E	19.3406	0.0476	0.0045	3	915	33	,,	0	0.25	0.75	1.0	,, ,,
Sp-4	19.4369	0.0559	0.0053	3	915	45	,,	0.2	0.25	0.65	1.1	,, ,,
S-10-B	19.3367	0.0690	0.0066	3	915	65	,,	0.3	0.3	0.65	1.25	,, ,,
S-10-C	19.3240	0.0740	0.0071	3	915	90	,,	0.4	0.25	0.65	1.30	,, ,,
S-10-D	19.3978	0.0787	0.0075	3	915	115	,,	0.45	0.25	0.7	1.40	,, ,,
S-10-V	19.4486	0.0700	0.0067	3	925	32	,,	0.5	0.3	1.0	1.80	Temperature control bad. Too high for series.
S-10-A	19.4885	0.0359	0.0034	2	915	45	,,	0	0.2	0.8	1.00	Fuse blown. Sp. 4 run to replace same.
S-10-W	19.5324	0.0976	0.0093	3	950 to 1000	45	,,	0.6	0.25	1.00	1.85	Temperature control bad. Too high for this series.

TABLE IX.—SERIES 11. ILLUMINATING GAS.

						lb.		mm.	mm.	mm.	mm.	
S-11-G	19.4964	0.0247	0.0024	3	810	40	5 litres per hour	0	0.2	0.3	0.5	Specimen very bright.
S-11-H	19.3985	0.0245	0.0023	3	805	65	,,	0	0.2	0.3	0.45	,, ,,
S-11-I	19.4796	0.0244	0.0023	3	805	90	,,	0	0.2	0.3	0.45	Specimen very bright. Grain growth.
S-11-J	19.2400	0.0253	0.0024	3	810	115	,,	0	0.2	0.3	0.45	,, ,,

TABLE X.—SERIES 12. ILLUMINATING GAS.

						lb.		mm.	mm.	mm.	mm.	
S-12-L	19.1488	0.0741	0.0070	3	990	26	5 litres	0.4	0.5	0.9	1.8	Specimen very bright.
S-12-M	19.3073	0.1109	0.0105	3	990	45	,,	1.0	0.5	0.75	2.25	,, ,,
S-12-N	19.5081	0.1207	0.0120	3	995	75	,,	1.3	0.5	0.8	2.6	,, ,,
S-12-K	19.1081	0.0493	0.0047	6½	800	27	,,	0.2	0.3	0.5	1.0	Voltage low, could not get 990, 800 max. Control bad.

in series, one cylinder having its intake connected to the exhaust of the other cylinder. The vacuum gauge is of the McLeod type, so constructed that 1 mm. difference in level in the mercury column gives a vacuum measurement of 0.00875 mm. of mercury. An ordinary dial type of vacuum gauge is also used to give approximate readings while the furnace is being exhausted. All exhausted air is thoroughly dried by $CaCl_2$ and P_2O_2 tubes before entering the pump.

The electrical control of the furnace and motor is centred on one board. At the top is the line switch and fuses. Below and on each side are switches, one operating the furnace circuit and the other the motor. An ammeter which is in the furnace circuit is also placed

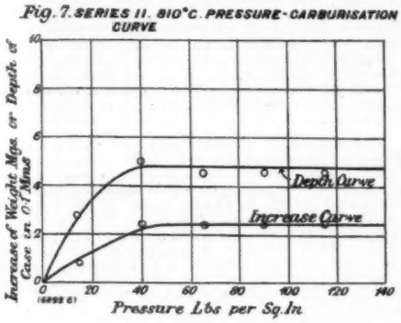


Fig. 7. SERIES 11. 810°C. PRESSURE-CARBURISATION CURVE

No. 1.—White Cast Iron, as received.

on the board. The starting rheostat for the motor is mounted below the ammeter. Terminals are provided at the base of the board for connecting the furnace, rheostat and motor.

The thermocouple for measuring the furnace temperatures is enclosed in a fused quartz tube which fits snugly into the iron pipe already described. A platinum platinum-rhodium couple is used, its electromotive force being measured by a Leeds and Northrup portable potentiometer. The cold junction can be maintained at zero by an ice-box. This arrangement allows of temperature readings with an accuracy of 5 deg. at 1000 deg. C.

The cycle of operations when the unit is operated as a vacuum furnace is something as follows:—After the desired charge has been made the plug is inserted and the valve next to the furnace in the pressure line is closed. The valves in the vacuum line are opened and the pump started. In about ten minutes the vacuum will be less than 0.1 mm. of mercury. The heating current is then turned on and the furnace brought to the desired temperature, which can easily be maintained by keeping the current constant. The pump is run continuously to take care of gases evolved from the specimens during heating and the slight leakage through the furnace jacket.

When operating the furnace under pressure more attention is required. The valves on the vacuum side are closed, the charge inserted, and the plug securely bolted in place. The compressor can be run either continuously or intermittently, as the experiment may demand, the object being to keep a higher pressure in the storage tank than in the furnace. The pressure in the furnace is controlled by means of the valve between the tank and the gauge, the gauge recording the pressure in the furnace. If for any reason the pressure in the tank is to be determined, the valve between the gauge and tank can be opened after first closing the valve between gauge and furnace. The reading now will be the tank pressure. The amount of gas passing through the furnace under any pressure is regulated by valves in the plug outlet at the opposite end of the furnace.

In certain observations it is convenient to operate the unit first as a vacuum, and then as a pressure furnace. For example, in determining the effect of a certain gas passing at a constant rate and temperature for a given time, evidently if the gas is started while the furnace is cold, the result obtained will show not only the effect produced at a certain temperature, but also the effect produced in heating to and cooling from the desired temperature. This is obviated as follows:—The furnace is exhausted when cold and then raised to the desired temperature. The gas desired is thus passed for the desired length of time, after which the furnace is again quickly exhausted and then allowed to cool. In this manner the effects produced in heating to and cooling from the working temperature can be almost completely annulled.

Experiments.—The following experiments (series 1 to 12 inclusive) were conducted in the furnace which has just been described. The material subjected to carburisation ensuing. For purposes of comparison this change of weight was divided by the area of the specimen, introducing a column in the data tables, "change of weight per square centimetre of surface."

Series 1.—The conditions were as follow:—City gas was passed at different rates and for different times at atmospheric pressure, the temperature being approximately 1000 deg. in all cases. The conditions and results are shown in Table I, page 448. The conclusive result from this series was that city gas under the conditions of experiment did not carburise. An examination of the furnace tube showed that carbon was being deposited, but not in the hot portion of the tube.

Series 2.—Series 2 was carried out as series 1, except

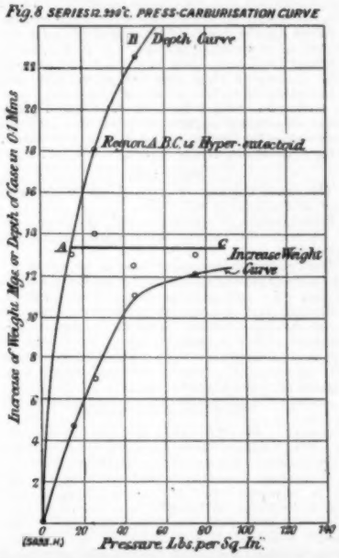


Fig. 8 SERIES 12. 900°C. PRESS-CARBURISATION CURVE

No. 2.—White Cast Iron, after decarburization.

burisation was without exception "ingot iron" supplied by the American Rolling-Mill Company of Middletown, Ohio. It had the following chemical composition:—

	Per Cent.
Carbon	0.01
Silicon	0.002
Sulphur	0.002
Phosphorus	0.003
Mangasnese	trace

The gases used were the city illuminating gas and acetylene.

The samples of iron to be cemented were turned down in a precision lathe to a uniform diameter (within 0.001 of an inch) and were approximately 0.45 in. in diameter and 0.85 in. in length. Every sample was accurately weighed and measured before and after treatment. In all cases where oxidation did not occur the change in weight was a sufficiently accurate measure of the car-

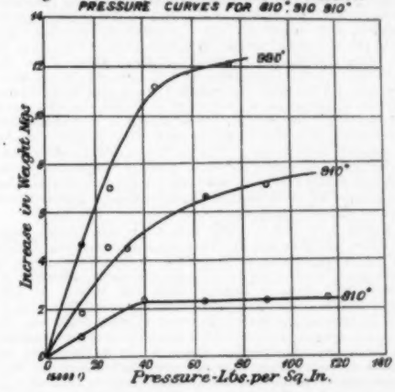


Fig. 9. SERIES 10.11.12 INCREASE OF WEIGHT. PRESSURE CURVES FOR 810°, 810 810°

that the temperature was reduced to 900 deg. C. The data for this series, Table II, page 448, gave results similar to series 1.

Illuminating gas is unfortunately a mixture of several systems, but some general chemical laws are applicable. All systems in which carbon is deposited follow the general law that the higher the temperature (within limits) the greater the amount of carbon in the gaseous phase. The following system is typical: $2CO \lesssim CO_2 + C$. At 500 deg. C. about one-half of a given volume of CO would be dissociated into CO_2 and C, while at 1000 deg. C. only 0.3 per cent. would be dissociated. In passing a given volume of CO through a tube held at 1000 deg. C. the following must occur. The cold gas enters the tube and becomes heated gradually. As soon as the reaction temperature is reached carbon will be deposited and will continue to deposit until equilibrium is reached for the temperature in question. The gas, however, is never permitted to reach equilibrium, as it is constantly changing temperature. If the rate of flow is not too rapid the gas will reach the hot zone impoverished in carbon, and to again reach equilibrium must absorb carbon from some source.

Series 3.—After an inspection of the results of the previous series the first inference would be that the gases in the hot portion of the tube would be decarburising. Carbon had been deposited from the gas mixture at lower temperatures to establish equilibrium, and as the temperature of the gas is raised carbon must again be absorbed to maintain the equilibrium condition. The only available carbon present in the hot zone is that of the austenite of the samples present, which will be absorbed.

A great many experiments were carried out on decarburisation, only one of which will be described.

A strip of white cast iron 1 in. by $\frac{1}{4}$ in. by 6 in. was treated at 1025 deg. C. for 10 hours, city gas being passed at the rate of 6 litres per hour. The white cast iron used in these experiments was furnished by the International Harvester Company and contained 2.5 per cent. carbon and 1.1 per cent. silicon.

Micrographs Nos. 1 and 2, annexed, show the bar before and after treatment. The carbon in the flat bar of white cast iron has been reduced from 2.5 per cent. to about 0.50 per cent. The structure reveals streamers of ferrite extending to the centre of the strip. This structure has been observed several times in decarburised specimens but has not yet been accounted for. This strip was bent 45 deg. before fracture occurred.

The other experiments on decarburisation with steels of varying carbon content showed the loss of weight per square centimentre of surface exposed to be a direct function of the carbon content. In all cases the decarburisation was not accompanied by any oxidation, the specimens all remaining very brilliant.

Series 4.—Following the failure of illuminating gas to carburise C_2H_2 was next tried. The conditions were maintained as in all the previous experiments. The temperature used was 1000 deg. C., the time constant four hours, and the rate of flow varied from 1.44 litre per hour to 10 litres per hour. The conditions and results for this series of experiments are summarised in Table III, page 448. The results show that no carburisation will result without a velocity of gas flow greater than 2.75 litres per hour. This condition is explained in a similar manner to the phenomena observed in series 1 and 2. The decomposition of C_2H_2 is a complex reaction and several products may be formed:—

$$2C_2H_2 = C_3 + CH_4$$
$$2C_2H_2 = C_3 + C_2H_2 \text{ \&c.}$$

C_2H_2 is more stable at 1000 deg. than at 400 deg. or 500 deg., and as a result carbon is deposited in great abundance in the cold end of the tube, and when the hot portion of the tube is reached the gas lacks the necessary carbon to be in equilibrium. At all rates sufficiently slow the above condition results and no carburisation occurs, but increasing the rate to 10 litres per hour does not allow sufficient time for the complete deposition of the carbon in the cold end of the tube. Consequently the gas arrives in the hot zone still rich in carbon, which is given up to the iron, forming austenite.

In order to study carburisation under equilibrium conditions, the following plan was used. The tube in which the specimens were treated was filled with solid carbon for about one-half its length. In this manner the gas was kept in equilibrium with solid carbon at the temperature desired to be used. The sketch on page 447, Fig. 2, represents the tube as used in all the following series. The gas enters at the end of the tube, deposits carbon, and passes on. As it reaches the hot zone and is in the condition to absorb carbon it is at liberty to do so from the carbon packing. Carbon passes from the solid state into combination with the gas, the result being equilibrium between the gaseous phase and solid carbon at the temperature at which it is desired to effect carburisation. The gaseous phase passes on and strikes the specimens, to which it yields part of its carbon, causing cementation to ensue. It was impossible to work with C_2H_2 under pressure, and consequently the portion of the work in which C_2H_2 was used was confined to determining the degree of carburisation under different rates of flow and at different temperatures.

Series 5, 6 *and* 7.—The following experiments were confined to this work. The results shown in Tables IV and V, and Table VI, page 448, are shown assembled in the form of a curve by a series of isothermals. (See Fig. 3.) From this curve it appears that the extent of carburisation is a direct function of the rate of flow, and all the isothermals, except the one at 985 deg., can be drawn as straight lines. If a line AB is drawn parallel to the *y* axis intersecting this series of isothermals, the points of intersection furnish further information. Evidently at all points on this line the rate of flow is constant, which enables a curve to be drawn between temperatures and degrees of carburisation as the variables. This curve (Fig. 4) has a decided break in the region 890 deg. to 900 deg. The interpretation of this break is that, for a constant rate of flow, carburisation suddenly increases if the temperature is raised from 890 deg. to 900 deg.

The region 890 deg. to 900 deg. is the location of the gamma-beta allotropic change in pure iron. The break in the curve is a very effective demonstration of the increased solubility of carbon in gamma iron, and, in the author's opinion, shows beyond a reasonable doubt the possible solubility of carbon in beta iron.

A micrograph of this series is shown (No. 3, page 452). Some have been insistent on the point that hydrocarbons give cases high in free cementite. This section shows quite the reverse, as in no instance do the cases exceed the eutectoid ratio.

Series 8 *and* 9.—In the next series of experiments illuminating gas was used as the carburising agent, the tube being filled for one-half its length with solid carbon, as explained before. All the specimens after treatment were perfectly bright and without a trace of oxidation. This condition made it possible to use the increase of weight as a direct measure of the carbon absorbed and also allowed of accurate measurements of the case depth.

As is shown in Table VII, the rate and time were constant, the temperature being the only variable. Two curves (Fig. 5) have been drawn from the data obtained, one showing the relation between temperature and increase of weight, the other showing the relation between temperature and depth of penetration of carbon. Micrographs Nos. 4 to 7, inclusive, show very clearly the increase of carbon absorption with temperature.

Both the curves in Fig. 5 show a change of slope in the region of 910 deg., which, interpreted in terms of solubility, must imply a less solubility in beta iron existing below 910 deg. than in gamma iron existing above 910 deg. At some point between 725 deg. and 810 deg. the process of carburisation no longer takes place. Although no point has been determined between 725 deg. and 810 deg., it is not unreasonable to suppose that the change from the beta to the alpha state has some influence on this phenomenon.

Series 10.—The temperature of this series was 910 deg., which was maintained constant, as were all other conditions excepting pressure, which was the variable. (See Table VIII, page 448.)

The curves shown in Fig. 6 never become parallel to the axis, but approach parallelism at 115 lb. The increase of weight curve requires no explanation. Pressure increases the absorption of carbon, rapidly as the pressure is first increased. Afterwards at higher pressures increments of pressure seem to have but little effect on the amount of carbon absorbed.

The depth of case curve, Fig. 8, has been plotted in two branches, which in reality are two curves overlapped to the point A. Curve OAB is the total depth of case curve. Curve OAC is the curve in which the ordinates are the thickness of the eutectoid and hypo-eutectoid layers. The region BAC is a hyper-eutectoid zone. From these two curves the conclusion is evident that any increase of thickness of case caused by raising the pressure above 25 lb. is due to an increase of the hyper-eutectoid shell and not to an increase of the lower carbon content portions of the case.

Series 11.—This series was conducted at 800 deg. From the data in Table IX two curves, Fig. 7, have been drawn, one showing the relation between change of weight and pressure, the other between thickness of case and pressure.

The first conclusion which can be drawn is that pressure increases the carbon absorbed up to a certain limit. Increasing the pressure beyond 40 lb. causes no further increase in the amount of carbon absorbed, the time and temperature remaining constant. The temperature of this series, as before stated, was in the vicinity of 800 deg. For every temperature the curve becomes parallel to the axes at a different pressure; the higher the temperature, the higher the pressure must be to produce this effect. Micrographs Nos. 8 to 12, page 452, inclusive, show the typical cases resulting from this series.

Series 12.—This series, which was conducted at 995 deg., was limited at a maximum pressure of 75 lb. The curves, Fig. 8, have been drawn as in the previous series. The curve for the increase of weight shows a tendency to flatten as in series 10 and 11. In Fig. 9 the increase of weight curves have been assembled and permit of the general statement that increase of pressure increases the absorption of carbon at all the temperatures studied. After a certain critical pressure is reached, the critical pressure depending on the temperature, increments of pressure cause no further increase in carburisation. The data for experiment 12 are shown in Table X and Fig. 8.

SUMMARY.

1. The furnace herein described has proved very convenient and simple of operation.

2. Experiments on carburisation and decarburisation were carried out, using both illuminating gas and acetylene.

3. The gamma-beta points seem to mark a sharp break in the carburisation curves for both city gas and acetylene. No carburisation ensued below 720 deg.

4. The effect of pressure on the degree of carburisation with the gaseous systems found in illuminating gas was different at different temperatures. It is indicated by the various curves that after a certain pressure is reached further increase of pressure will not cause additional absorption of carbon by the iron.

PERSONAL.—A-L Meteorlite, Limited, of 106, Victoria-street, Westminster, have amalgamated the whole of their business and undertaking with their allied company, Allen-Liversidge Portable Acetylene Company, Limited, which is now styled "Allen-Liversidge, Limited."—Messrs. Léon Plaut, of Moscow, sole agents in Russia for W. and T. Avery, Limited, Birmingham; Hadfields, Limited, Sheffield; the Stirling Boiler Company, Limited, London, &c., have opened offices in London at 40, Granville House, Arundel-street, Strand, W.C. 2.

AEROPLANE ENGINES.—In a paper recently read before the Aeronautical Society Mr. L. Coatalen drew the following distinctions between engines for motor cars and aeroplanes. For car engines:—(1) Weight is practically no object. (2) Cost is of the utmost importance, therefore there must be the minimum of machining, as instance the fact that the connecting rods of a motor-car engine are not milled, nor are the crankshafts machined all over. (3) It must be capable of production in great quantities at minimum cost; otherwise, with the least amount of labour. (4) It must be silent to the extreme of what is practicable. (5) The maximum effort of which the engine is capable is not needed to be maintained for long at a spell. It seldom works at full power, and the brief duration of such effort explains the extraordinary reliability of even the inferior types of car engines. (6) Flexibility, giving a constant torque at a crankshaft speed from 300 revolutions a minute to 1,600 revolutions a minute. (7) Of course this is a torque which corresponds to a very low mean effective pressure, namely, 80 lb. (8) The compression is relatively low and the valve area small, the cam forms being easy and the valve springs light. (9) The system of lubrication, wherein the oil is carried in the base-chamber of the crank case, suffices. (10) The maximum horse-power required to be developed by any one engine rarely approaches 100. In the vast majority of cases it does not exceed 30. By contrast, the factors governing the design of an aircraft engine may be enumerated thus:—(1) Weight is of prime importance. (2) Cost is not the deciding factor provided the necessary amount of power is obtained for the given overall dimensions of the engine, for its weight both as regards material and fuel, water and lubricant consumption; and that the desired degree of reliability is obtained. (3) The amount of labour necessary to produce a satisfactory aircraft engine of high output is, and will be, always many times what is necessary in the case of a car engine, and is a matter of secondary importance provided the desired results are obtained. No machining is too expensive if it saves weight. (4) Silence is relatively unimportant. (5) The aircraft engine does all its work at practically full power. (6) Flexibility, or constancy of torque, is of very secondary importance, because an aircraft engine is required to work at practically one speed only, or, at most, at an extremely narrow range of speed. (7) But its working range of speeds is such as to call for a very high brake mean effective pressure, say, 130 lb. (8) The compression must be relatively high and the valve area large, while the valve springs must be stronger than for a motor car, due to the cam form imposed. (9) The high mean effective pressure necessary, coupled with the fact of the engine doing nearly all its work at full power, involves a completely different point of departure in determining details of design and, notably, the exploitation of new methods of achieving lubrication. Experience has demonstrated abundantly that when the base-chamber is used as an oil well, as in motor-car practice, the lubricant soon becomes too hot, therefore too fluid; hence the evolution of the dry sump system for lubricating aircraft engines.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—The pressing demand for all classes of steel being so very great, numerous manufacturers are experiencing considerable difficulty in fulfilling the orders in hand with anything like the required promptness. Great things were expected when all the new plant was in working order, but unfortunately the shortage of labour has occasioned so great an amount of delay that the extensions and additions being made are not yet of the contemplated value. The entire output in the West of Scotland is swallowed up immediately upon production. The work undertaken by the Clyde shipbuilding yards for the Shipping Controller and the Admiralty is another very heavy source of demand, large quantities of steel being in constant request alike for these orders and those of other Government departments. While home rates remain unaltered, those for export are in many cases purely a matter of arrangement, although the current quotations for steel ship plates are about 14*l.* 5*s.* per ton, for boiler plates 15*l.* 12*s.* 6*d.* or thereabouts, and for angles 14*l.* 2*s.* 6*d.*; all, of course, subject to grading.

Malleable Iron Trade.—Malleable iron makers are still so well supplied with orders that the greatest activity prevails, every mill running at its fullest capacity. Most of the work, of course, is on Government account, either directly or indirectly, export being in the meantime practically a sealed book. The limitation of facilities for shipping contribute in no small degree to this falling-off in the matter of export, at least so far as the iron products are concerned, steel, owing to Government restrictions, being still barred from shipment abroad. Prices keep steady, the current quotation for "Crown" bars still standing at 15*l.* 5*s.* per ton.

Scotch Pig-Iron Trade.—During the week little change has taken place in the pig-iron trade, makers being very busy, and the demand for all grades, particularly hematite, continuing unabated, principally for home consumption. Forge and foundry iron are also much in request, although No. 1 is still very scarce. Shipments abroad are virtually at a standstill, no licences being granted for neutrals, and only small quantities going to the Allies. No change has taken place in price, either for home or export.

Resignation of Clyde Labour Official.—Much regret is being expressed at the resignation of Mr. W. G. Sharp, organising delegate of the Boilermakers' Society, who, in view of his acceptance of an appointment as technical adviser to the Shipbuilding and Engineering Employees, is severing his official connection with the various labour activities with which he has been closely identified for some years. Mr. Sharp has held several important positions in the local trade-union movement, having been chairman of the Clyde District Committee of the Engineering and Shipbuilding Trades Federation, and also of the Labour Advisory Board in the Clyde area.

Mid-Scotland Ship Canal.—In view of the fact that details and estimates for the proposed Mid-Scotland Ship Canal from the Forth to the Clyde, via Loch Lomond and Loch Long, are now complete and, having been submitted to a Government Department, have been favourably considered, meetings have been held in Glasgow during the past week to protest against this route being selected in preference to "the direct route, which would secure a navigable passage between the North Sea and the Atlantic." It was pointed out that, both for the purposes of State and of commerce the direct route would be the more advantageous of the two, and a resolution to this effect was passed, arrangements being made to send copies to the First Lord of the Admiralty, the local Members of Parliament and the town clerk.

NORWEGIAN SHIPBUILDING.—In 1916 there were built in Sweden 46 steamers of 37,478 tons gross register. The Aktieselskapet Fredriksstads Mekaniske Verstad headed the list.

PROPORTIONING CONCRETE.—In a paper recently read before the Concrete Institute Mr. H. C. Johnson observes that the amount of cement in a 1 : 2 : 4 concrete may range between 18 per cent. and 24 per cent. of the total volume of the mixture. For example, if gravel be used as the aggregate in one case and broken stone in another, 130 tons of dry cement would be required for the broken stone concrete where 100 tons would suffice with the gravel aggregate. On the other hand, the gravel aggregate would be 12 per cent. to 15 per cent. weaker. Further, a ¾-in. aggregate concrete is stronger than one made with ½-in. aggregate, and 1½-in. aggregate is stronger than either. Volume for volume, the surface of the ¾-in. aggregate is 500 per cent. more than that of a 1½-in. aggregate. He suggests that in place of specifying 1 : 2 : 4 concretes regardless of the aggregate, the specification should provide that the volume of dry cement used should be a specified proportion of the total final volume of the mixture. This would make the weight of cement used the same per cubic foot whatever the aggregate. With large aggregates he suggests that the proportion of sand should be diminished, being fixed by the "workability" and weight per cubic foot of the concrete. Tests made in this connection show, the author states, that the percentage of cement to the total volume closely governs the strength. Incidentally it is noted that the washing of average aggregates increases the strength of hand-mixed cement by 30 per cent. to 40 per cent., whilst with machine mixing the gain is but 15 per cent. to 25 per cent. It was also found that when the quantity of cement per cubic foot of mixture was the same, gravel concrete was as strong as broken stone concrete.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—There is no pronounced change on the week, for there is still a great excess in the quantity required compared with the tonnage on offer. The easement in the house coal market is only slight on the whole, and does not materially affect the general position. The largest demand exists for the best qualities of steam hards. Works and railway companies have placed big orders, both on account of contract and in the open market, but there is not much possibility of all requirements being satisfied at present. There is little at all offering outside contracts, and the bulk of this is being diverted to export, where the prices accruing are about 8*s.* more than those for inland sales. Gas companies are sharing the general difficulty in getting supplies, though their contract orders are arriving fairly regularly. The market for cobbles, nuts and slacks is very brisk. Gas and furnace cokes are in great demand, and prices remain at top values. Quotations:—Best branch hand-picked, 20*s.* 6*d.* to 21*s.* 6*d.*; Barnsley best Silkstone, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire best brights, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire house coal, 17*s.* to 18*s.*; best large nuts, 16*s.* 6*d.* to 17*s.* 6*d.*; small nuts, 15*s.* 6*d.* to 16*s.* 6*d.*; Yorkshire hards, 16*s.* 6*d.* to 17*s.* 6*d.* Derbyshire hards, 16*s.* to 17*s.*; best slacks, 12*s.* to 13*s.*; seconds, 10*s.* 6*d.* to 11*s.* 6*d.*; smalls, 7*s.* 6*d.* to 8*s.* 6*d.* per ton at the pit.

Iron and Steel.—The expected advance in the maximum price for common irons has not yet taken place, and there is a belief that the makers will have to make out a good case before anything definite will be done in the matter. A new departure, and one not altogether expected, is the request on the part of the manufacturers of high-speed steel for an increase in the prices allowed to be charged for their product. At the present there is a specific scale for high-speed steel containing either 14 per cent. or 18 per cent. tungsten, but the makers of the better quality contend that they are not to-day sufficiently repaid by these rates in view of the gradually advancing prices they have to pay for base materials. It was long ago a matter of dispute between the Government, as represented by the Ministry of Munitions, and the firms that the fixed tariff did not repay makers for the production of the superfine high-speed steel, and that something extra should be allowed for these grades. The Ministry never conceded the point, but it is considered that something may be done in the matter now which will remove the grievance the makers consider they have. At the present time the call for all qualities of high-speed steel is very heavy, and exacting demands are made upon the High-speed Alloys Company for the supply of the necessary tungsten powder. It is estimated that the ore mines, both in Australia and Burma, are producing much more than was expected under the most generous survey, and are likely to increase this yield in the course of time. The material market maintains its strong tone. Buying is on a large scale, and there seems to be no difficulty in works disposing of the full extent of their production, and at top values. The current quotations, with delivery at local works, are as follow:—Lincolnshire forge, foundry and basic, 97*s.*; Derbyshire forge, 92*s.* 6*d.* to 93*s.*; Derbyshire foundry, 94*s.* 6*d.*; Bessemer acid billets, up to 14*l.* 10*s.*; Siemens acid, 15*l.* 10*s.*; hard basic, 11*l.*; and soft basic, 10*l.* 10*s.* to 11*l.* Some classes of steel have an easier tendency, but, generally, there is tightness all round. There is not the same quantity of Swedish material offering as in the early period of the present year, owing to the somewhat scanty importations, but it is felt that the stocks in the country are in every way very substantial. It should not be forgotten that much of the Swedish material held in reserve is on account of contracts made for some time ahead, and is, therefore, not for disposal on the open market. Glasgow Corporation has placed tramway track work with a large firm here. Beyond direct war work, which only amounts to a small proportion of the bulk of orders received, the cutlery and plate firms are limited in their activities for want of material. Overseas trade continues to be good. The latest indents are for tools, files, saws, picks, hammers, sheep shears, hardware, grinding machinery, steel and cutlery.

Sheffield University.—The Court of Governors of the Sheffield University met on Monday, May 7, when new ordinances relating to the establishment of the new faculties of engineering and metallurgy, in place of the combined one of applied science, were adopted. The vice-chancellor, Professor Ripper, in proposing the adoption, mentioned that Mr. W. H. Ellis, the Master Cutler, and a member of the firm of Messrs. John Brown and Co., and Mr. G. Blake Walker were to be members of the faculty of engineering, and expressed pleasure that it had been possible to include two such valued members of the University Council and such distinguished members of the engineering profession. A second point to which he directed attention was an alteration of interest to the pupils. He said that in the past the day students had not been able to obtain the associateship of the university, which was a distinction of some value to the young engineer. They had not taken a sufficient number of lectures or attended a sufficient length of time to qualify them for the examination. On the other hand, evening students had had in the past, and still had, the power to take the associateship if they attended long enough, the minimum period being four years. It was now proposed that day students who came from the works should be allowed to attend for a fourth year, and accordingly qualify for the associateship. It was believed that this alteration would be greatly appreciated by both the students and the firms.

WOLFRAM IN BOLIVIA.—Wolfram ore totalling 49½ tons was mined in the Aramayo Francke mines last year.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—There is a good deal of activity in Cleveland pig-iron, but it is almost entirely of the stereotyped kind to which traders have become accustomed. There is no dearth of iron, and under the May allocations, which are on such a scale that all applications are being met, deliveries to home users and to customers in Scotland are proceeding smoothly, and promise to be very heavy this month. The recent marked improvement in the truck supply is greatly facilitating distribution. Inquiries from abroad do not lead to much business, owing to the tonnage situation. Shipments to our Allies are in arrear, but iron is being loaded as expeditiously as circumstances permit. For home consumption No. 3 Cleveland pig, No. 4 foundry, and No. 4 forge are all quoted 92*s.* 6*d.*, and No. 1 is put at 96*s.* 6*d.*; and for shipment to France and to Italy No. 3 is 102*s.* 6*d.*, No. 4 foundry 101*s.* 6*d.*, No. 4 forge 100*s.* 6*d.*, and No. 1 107*s.* 6*d.*

Stocks of Cleveland Pig-Iron.—Makers' stocks of Cleveland pig-iron are not known, but they cannot be at all large, and the quantities at consumers' yards are understood to be small. The stock in the public warrant stores has shown no change since the 30th of last month, when 120 tons of No. 3 were withdrawn, and stands at 1,997 tons, composed of 1,991 tons of No. 3 quality and 6 tons of other descriptions of iron deliverable as standard. There are now warrants in circulation for only 1,750 tons, all of which is No. 3 iron.

Hematite Iron.—Little new is ascertainable concerning the East Coast hematite branch of the pig-iron trade. All legitimate home needs are receiving adequate attention, and deliveries are now regular, whilst negotiations for further contracts are proceeding, but foreign business is very quiet. Sellers still protest that recognised market rates, and especially those for export, were much below what they should be under the conditions prevailing, and they are more pronounced than ever in their claim for advances. Opinion continues to differ as to whether the authorities will sanction higher quotations, but the general view is taken that the situation demands some readjustment. Nos. 1, 2 and 3 are 122*s.* 6*d.* for home use, 137*s.* 6*d.* for shipment to France, and 142*s.* 6*d.* for export to Italy.

Coke.—Values of descriptions of coke needed for the blast-furnaces are kept at the fixed maximum prices notwithstanding the plentiful supply. Home demand is heavy, local requirements being very considerable. Average furnace kinds are 28*s.* at the ovens, and low phosphorus qualities 30*s.* 6*d.* at the ovens.

Manufactured Iron and Steel.—Finished iron and steel manufacturers are very busily employed, and are still increasing output. Government needs absorb the greater portion of production, but the manufacture of mercantile shipbuilding material is heavy and growing. Quotations all round are very firm. The following are among the principal market quotations to home customers:—Common iron bars, 13*l.* 15*s.*; best bars, 14*l.* 2*s.* 6*d.*; best best bars, 14*l.* 10*s.*; iron ship plates, 13*l.* 10*s.* to 14*l.* 10*s.*; iron ship angles, 13*l.* 15*s.*; iron ship rivets, 18*l.* 10*s.*; packing iron and steel (parallel), 13*l.*; packing iron and steel (tapered), 15*l.* 5*s.*; steel bars (no test), 14*l.* 10*s.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel ship rivets, 20*l.* and upward; steel boiler plates, 12*l.* 10*s.*; steel joists, 11*l.* 2*s.* 6*d.*; steel strip, 17*l.*; steel hoops, 17*l.* 10*s.*; and heavy sections of steel rails, 10*l.* 17*s.* 6*d.*

Blast-furnacemen's Wages.—A claim by blast-furnacemen for 1*s.* per day additional war bonus was considered at a joint meeting of Cleveland Ironmasters and the executive of the Cleveland and Durham Blast-furnacemen's and Cokemen's Association, held at Middlesbrough this week, and it was agreed to concede that amount to all men whose wages are not regulated by the sliding scale. The ironmasters were not prepared to concede a similar advance to the sliding-scale men, but made an offer to double the war bonus granted to all sliding-scale men in March, 1915. This the Blast-furnacemen's executive refused to accept, and the men's association intends to request the Ministry of Munitions to deal with the question.

CANALS.—In England and Wales there are 3,639 miles of canals and in Ireland 848 miles. Of these, 1,363 miles are owned by railway companies. In England and Wales there are 2,377 locks, and 16 tunnels between 1,000 yards and 3,808 yards in length.

BRITISH MAGNETOS: ADDENDUM.—With reference to the article on "British Magnetos" which appeared on page 405 *ante*, and to the statement made therein that the fine varnished silk used for insulating the armatures was imported from America, we are informed by Messrs. Abbott, Anderson and Abbott, Limited, of Dod-street, Burdett-road, London, E. 14, that they are makers of this material, and are now supplying it to Government orders for aeronautical purposes. The firm have also sent us samples of varnished silks and cambrics of their manufacture, which appear to be of excellent quality, and they inform us that the insulating properties of their varnished silk are such that a sheet 4 mils in thickness will withstand a pressure of 8,000 volts, whereas a similar specimen of American manufacture broke down at about 4,000 volts. We are pleased to give publicity to these facts, which show that British magneto manufacturers are not dependent upon imported supplies of this material.

NOTES FROM THE SOUTH-WEST.

Cardiff.—The coal market has recently been somewhat erratic. Towards the end of last week there was an appreciable advance in the quotations, and a firm undertone prevailed until Tuesday of this week, when there was experienced a sharp reaction in the quotations of practically all descriptions of coal. Sellers were asking for 30*s.* for second Admiralty descriptions, but were ready to agree to prompt sales at 1*s.* or more under that figure. Monmouthshire Western Valleys changed hands at less than 27*s.* 6*d.*, while cargo smalls were done under 13*s.* 6*d.* The cause for the sudden change was the slump in the supply of tonnage. The immediate effect of this shortage was the release of Admiralty coals, but the market has little use for released coals where there is no shipping to carry it away, and the offers of supplies at reduced prices meant nothing more than an attempt to secure sufficient empties to keep the pits at work. There were salesmen who were prepared to adhere to the limitation figures at the expense of idle days at the collieries, for below those figures, at current cost of production, it is unremunerative to work the South Wales collieries. Salesmen, however, feel that they cannot act independently, and it is feared that it will be by a system of fixed prices that the evil of selling at a loss can be avoided. Though still on the easy side, the market by Wednesday was not quite so weak, second Admiralties being 27*s.* and 27*s.* 6*d.*, and inferior qualities slightly lower, but little or no disposition was apparent to accept orders even for next week at these lower levels. Hopes are entertained of a better supply of tonnage at an early date. For best bunker smalls 20*s.* is still being quoted firmly, and this price is being obtained, but other descriptions of smalls are appreciably easier, with the inferior drys ruling down to about 12*s.* 6*d.* or 13*s.* Quotations for coke, fuel, pitwood and iron ore remain at their fixed levels.

Newport.—As far as possible salesmen are endeavouring to resist reaction in prices by adhering to their limitation quotations and declining to sell ahead at the price offered by buyers. In isolated cases, however, collieries have been prepared to accept on the basis of about 27*s.* 6*d.* for Western Valleys, and at a shade lower figure for Eastern Valleys. The cycle of reduced tonnage supplies is likely to prove one of short duration, and the market is anticipating an improvement in the supply of shipping next week. Through coals are easier in sympathy, and smalls are also obtainable at figures from 1*s.* to 2*s.* 6*d.* under those prevailing last week.

Regulation of Coal Traffic.—A scheme has been arranged by the District Coal and Coke Supplies Committee for South Wales and Monmouthshire, and Mr. I. J. Anthony, the district inspector, appointed for the direction of coal traffic in the district. Owing to reduced railway facilities, and with the object of reducing to a minimum the mileage in the transport of coal, it has been arranged that the coal produced in the South Wales coalfield shall, as far as possible, be shipped at the nearest port to each colliery, and that home consumers should obtain their fuel requirements from the nearest sources of supply. A detailed schedule has been prepared giving the names of collieries and colliery companies, and the ports at which the coals produced at such should, as far as practicable, be shipped.

The Supply of Pitwood.—The Controller of Mines has just completed a scheme by which the control of pitwood supplies for the different collieries is placed under the direction of local committees. For South Wales the committee will consist of Mr. J. Dyer Lewis (the Chief Inspector of Mines) as chairman; Messrs. B. Nicholas, Evan Williams, W. North Lewis, W. Stewart and Finlay A. Gibson (representing the Coalowners' Association); Mr. J. W. Randall (of the Dunraven Estate), representing the forest owners; Mr. A. J. Griffith (Bute Docks, Cardiff), representing the Admiralty; and Mr. H. A. A. Phillips (Swansea), as technical adviser to the chairman.

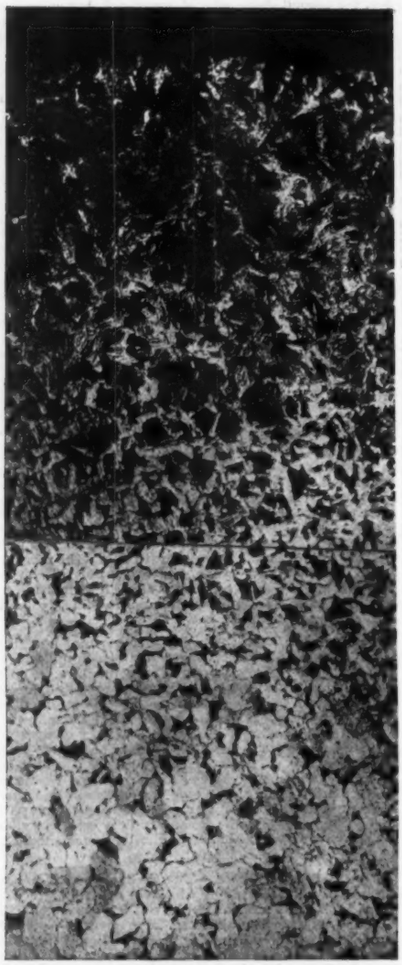
RAILWAY SLEEPERS.—A report from Nicaragua states that the country provides 16 varieties of timber suitable for railway sleepers. A million sleepers a year could be obtained from the Conseguina Peninsula alone. Rough-hewn sleepers, 7 in. by 8 in. by 9 ft., would cost about 20*d.* alongside ship. At Corinto the price would be increased by railway charges and wharfage, &c.

DYNAMO-COMMUTATION AND FRAME VIBRATIONS.—Trouble with the commutators of dynamos and electric motors is sometimes merely due to the vibration of the base. *The Electrical World* of February 24, 1917, reports one such case, in which elaborate adjustments were tried until a steam-turbine man noticed that oil was breathing out between the bearing cap and the pedestal of the middle bearing. Two iron wedges were driven under the centre of the base on opposite sides of the machine; the sparking ceased, and the note given out by the machine became different.

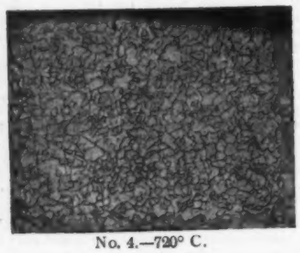
RAILWAY SNOW FENCES.—The Minneapolis, St. Paul and Sault Ste Marie Railway is experimenting with screens of trees to act as snow fences. Eight rows of trees are planted on the north side of the line and four on the south side. The rows are 8 ft. apart, and the trees in the rows 3 ft. to 4 ft. apart. Starting from the line on the north side the rows are respectively willow, willow, willow, box elder, green ash, poplar and carragana. The prairie is ploughed and harrowed twice, and then left till next year. Twelve men in a ten-hour day planted about 2,000 trees at first. Then a machine, something like a potato planter, was devised by which 20,000 trees could be planted in a day at a cost of 1*d.* apiece.

CEMENTATION BY GAS UNDER PRESSURE.

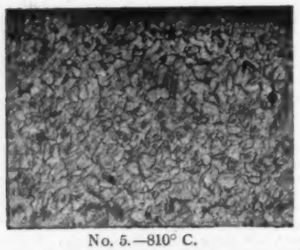
(*For Description, see Page 447.*)



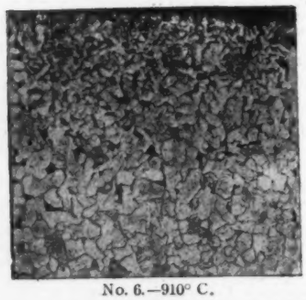
No. 3.—Armco Iron Carburised 4 hours in C_2H_2 at 1000° C.



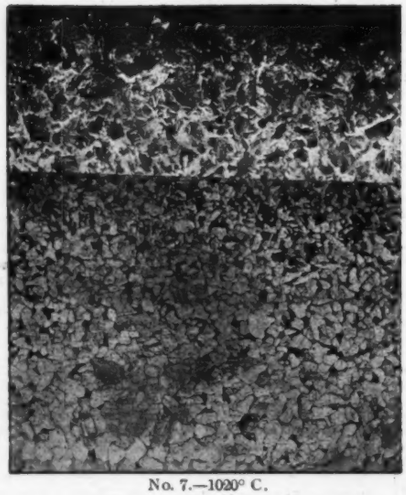
No. 4.—720° C.



No. 5.—810° C.

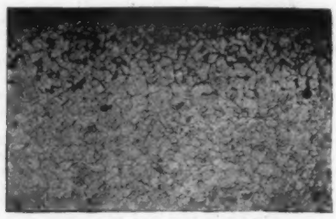


No. 6.—910° C.



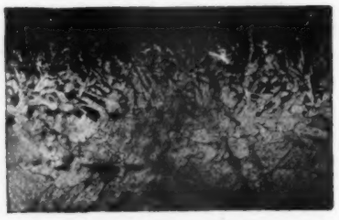
No. 7.—1020° C.

NOS. 4 TO 7 SHOW DEPTH OF CARBURISATION OF ARMCO IRON IN ILLUMINATING GAS AT TEMPERATURES FROM 720 DEG. C. TO 1020 DEG. C. AT ATMOSPHERIC PRESSURE.

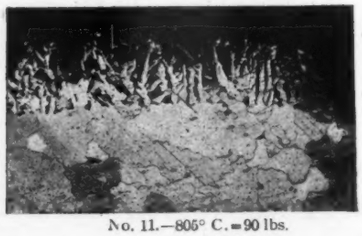


No. 8.—810° C. = 15 lbs.

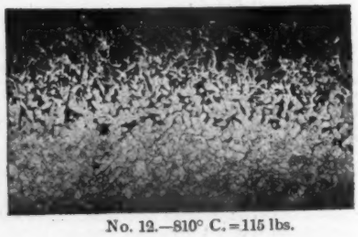
No. 9.—810° C. = 40 lbs.



No. 10.—810° = 65 lbs.



No. 11.—805° C. = 90 lbs.



No. 12.—810° C. = 115 lbs.

NOS. 8 TO 12.—SHOWING DEPTH OF CARBURISATION OF ARMCO IRON EXPOSED TO ILLUMINATING GAS AT 800 DEG. C. TO 810 DEG. C., UNDER DIFFERENT PRESSURES.

GERMAN STANDARD ROLLED SECTIONS.—The scarcity of labour, as well as that of iron and steel, has made it expedient for the German Government to modify the extensive list of standard rolled joists, girders, and other sections. To this end the principal consumers have been officially asked to make selections of the most useful and necessary sections, and from the data thus accumulated a new standard list has been compiled. By an official decree, all specifications for structural, as well as other engineering work, issued on and after January 10, 1917, are compelled to be confined to the sections in this new schedule. The reason for this movement is obvious, as it involves the keeping of a smaller stock, quicker delivery, and less waste. The H-sections, which used to be in evidence in 50 to 60 different sizes, are now reduced to 18, whilst the channel sections, which used formerly to be rolled in 30 to 40 sizes, are now confined to 12, and all other sections, such as angles and tees, are reduced in like manner. Much time will thus be saved in changing rolls, and the output of the mills will be increased without any additional demand for skilled labour.

GERMAN PAPER PIPES.—An interesting example of the many efforts made in Germany to counteract their shortage of raw material is the manufacture of paper pipes, and the official experiments which have been made with these substitutes for iron piping are not without interest. Though these experiments have not yet been concluded, we learn that one kind of paper pipe, known as the "Pertinax" pipe, is built up of paper strips wound spirally round a core-pin and secured in that position by saturation with a synthetic gum, and afterwards the core-pin is withdrawn. During this process both heat and pressure are applied. The tests, so far as they go, show that such paper pipes will resist an internal pressure three to four times as great as that of lead pipes of nine times the weight of the paper pipes. In comparison with copper pipes under similar tests it was found that pipes of the same weight can withstand the same internal pressure. As regards the behaviour of the pipes towards the substance conveyed in them it is believed that they will be a success for gas and oil. It has been ascertained that some of the earlier types of paper pipes absorbed a great deal of moisture, but this, it is stated, can be prevented by a more perfect saturation and a judicious choice of the medium with which they are saturated. Some of the more recent examples of these pipes are being tested with hot water under pressure. As the gum used for the latest developments of these pipes will resist oil, it is intended to use them for lubricating purposes, especially as they can be made of diameters as small as $\frac{3}{8}$ in. to $\frac{1}{4}$ in.; it is also intended to employ these pipes, in addition to their use for gas, for insulating electrical wires, in a similar way to that in which lead pipes are now used.

"GROUND ICE" AT THE GREENOCK WATERWORKS.

(*For Description, see Page* 441.)

FIG. 4. SOLID BLOCK OF "GROUND ICE" OVER THE OUTLET SCREENS.

FIG. 5. SOLID BLOCK OF "GROUND ICE" VIEWED FROM THE SHORE.

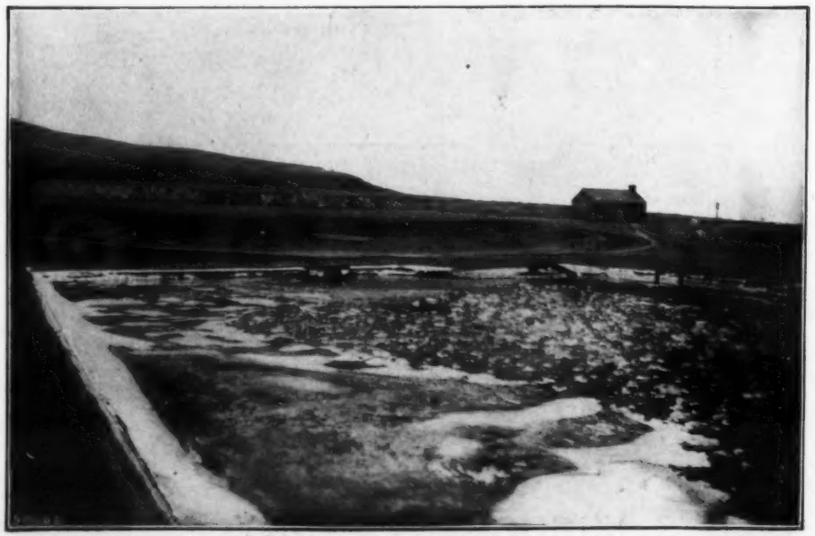


FIG. 6. WATER BEING RUN OFF A FILTER-BED.

FIG. 7. FILTER-BED RUN DRY.

(*To face page* 442.)

AMERICAN WOODEN SAILING SHIPS WITH AUXILIARY MOTORS.

(For Description, see Page 442.)

Fig. 2.

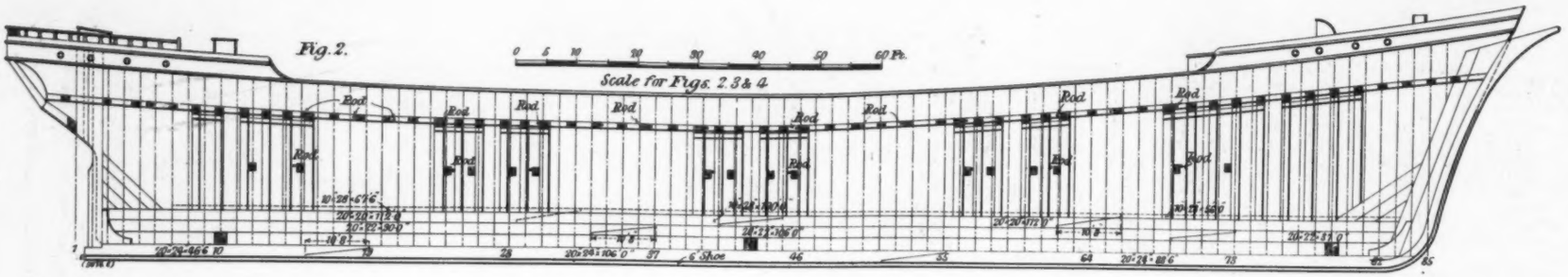


Fig. 3.

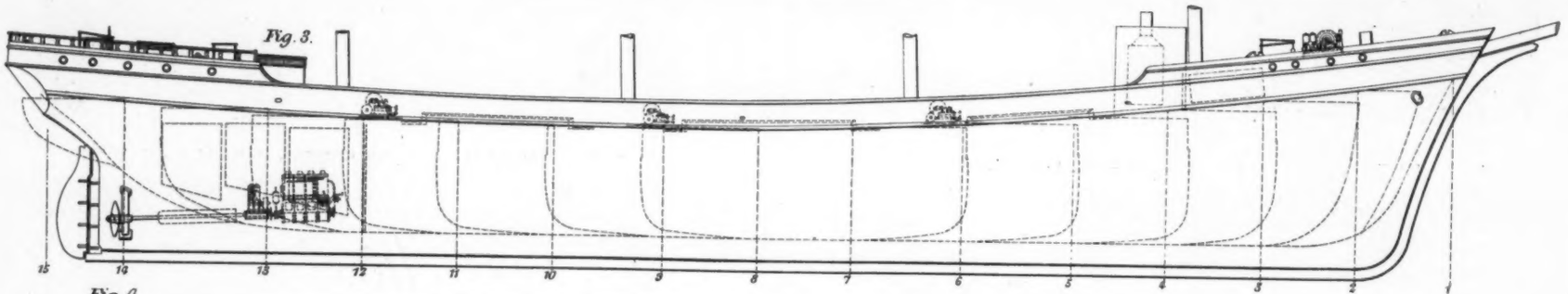


Fig. 4.

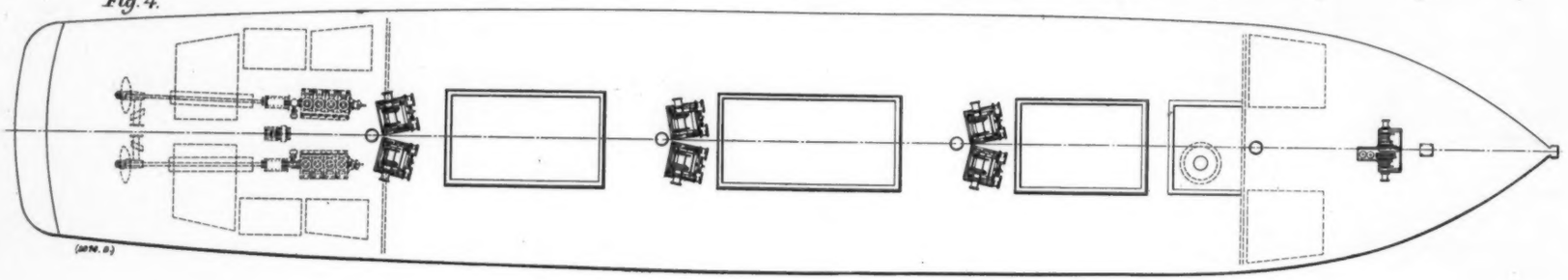
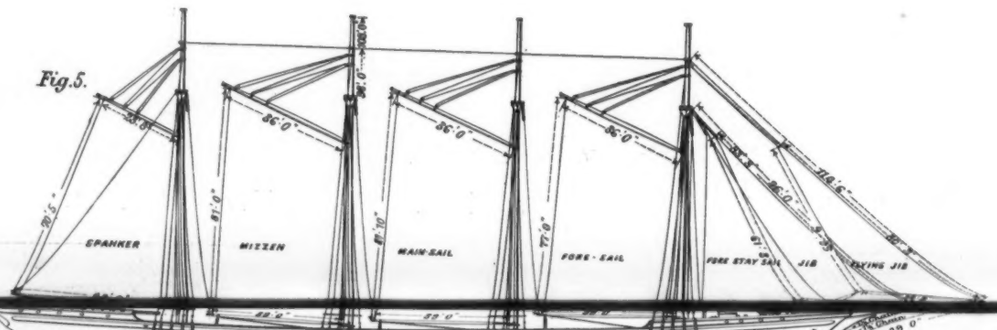


Fig. 5.



FIGS. 2 TO 7.

Length over all ..... 250 ft.

PARTICULARS OF MASTS AND SPARS.

Length of masts to be as per note on mizzen mast. Diameter of masts at step, 24 in.; partners, 26 in.; hounds, 21 in.; spring stay bands, 14½ in.; trucks, 6 in. Shrouds to light over bolsters as shown. Bolsters to set over cheeks and taper hound band. Short crosstrees fitted as shown to take eyebolts for throat halyard and topping lift blocks. Spring stay bands to have four distinct eyes and shackles for spring stays and tapered hound bands.

FIGS. 2 TO 7.

Length over all	...	250 ft.
Length of keel	...	220 ft.
Breadth moulded	...	43 ft.
Depth moulded	...	21 ft.

DIMENSIONS OF SHIPS ILLUSTRATED BY FIGS. 8 TO 17.

Length over all	...	290 ft.
Length under deck	...	274 ft.
Length between perpendiculars	...	268 ft.
Beam, extreme	...	48 ft.
Beam, moulded	...	46 ft. 10 in.
Depth, moulded	...	26 ft. 9 in.
Depth of hold	...	24 ft. 6 in.

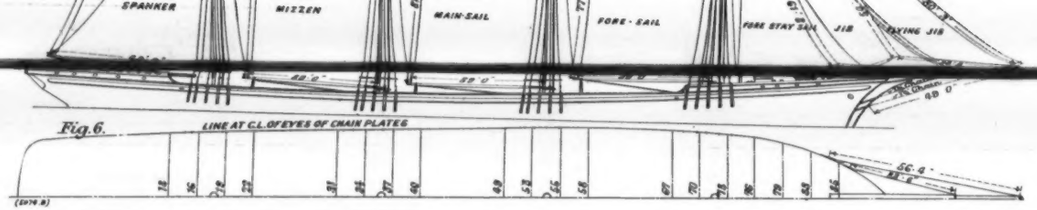


Fig.6.

Fig.7.

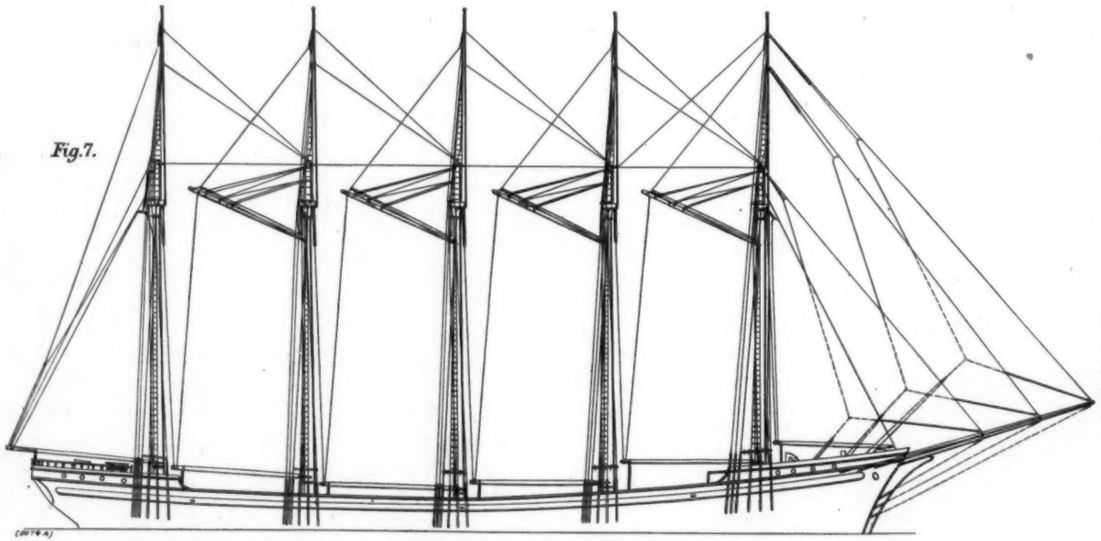


Fig.8.

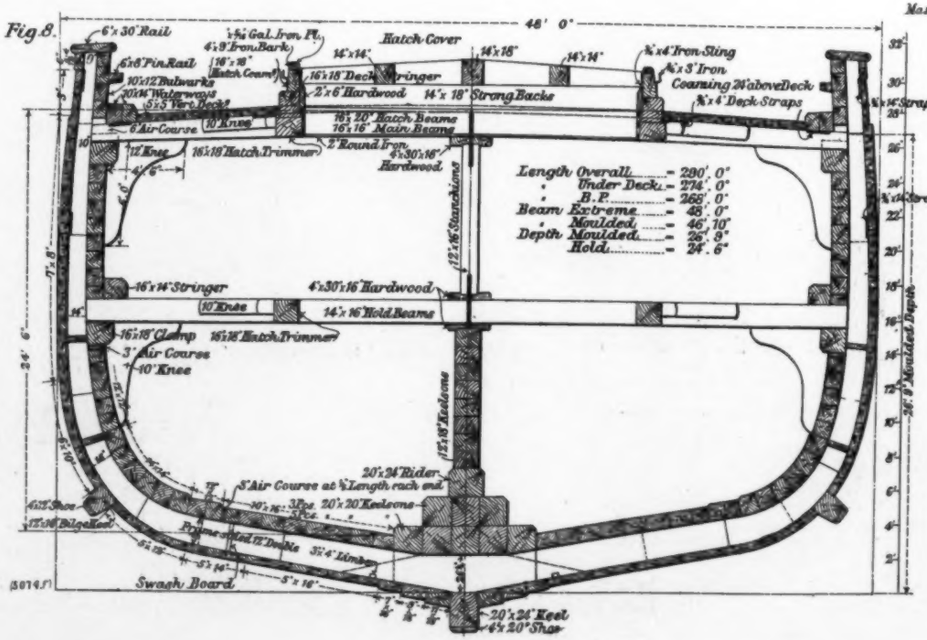


Fig.9.

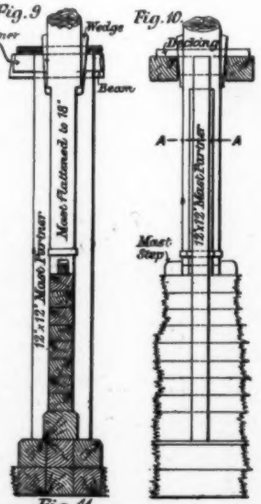


Fig.10.

Fig.11.

Fig.12.

Fig.13.

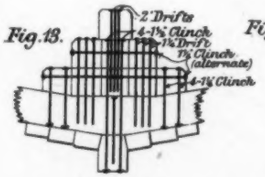


Fig.15.

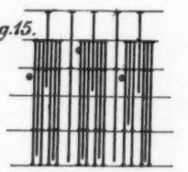


Fig.14.

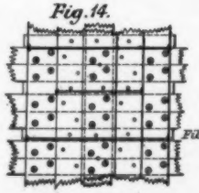


Fig.16.

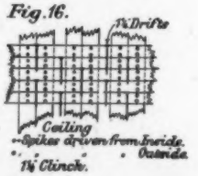


Fig.17

Booms and gaffs to be as shown. Jaws and tongues to be of ironbark. Saddle bands for booms to be of hardwood and set up with split cinch band.

BOWSPRIT.

Sizes as shown. Length to be measured as per note. Butt to tenon into pawl post. Outer and inner bands to set up on taper wedge bands.

SHROUDS AND STAYS.

Lower ends of shrouds to be fitted with iron-heart, with eye for sheer pole. All stays measured between the eyes. Double forestay to bight over bolster and lead to eyebolts at tops of knight heads and seized together.

SAILS, TARPAULINS AND MAST COATS.

Canvas and all coats, covers and tarpaulins to be of best Woodbury duck. Fore, main, mizzen and spanker sails measured between eyes of clue bands and staples on booms and gaffs. Head sails measured between thimbles. All sails cut to suit spars. Fore, main and mizzen sails to have two reefs and a lumber reef. Spanker two reefs only.

THE DETERIORATION OF TURBINE BLADING.

(*For Description, see Page* 461.)

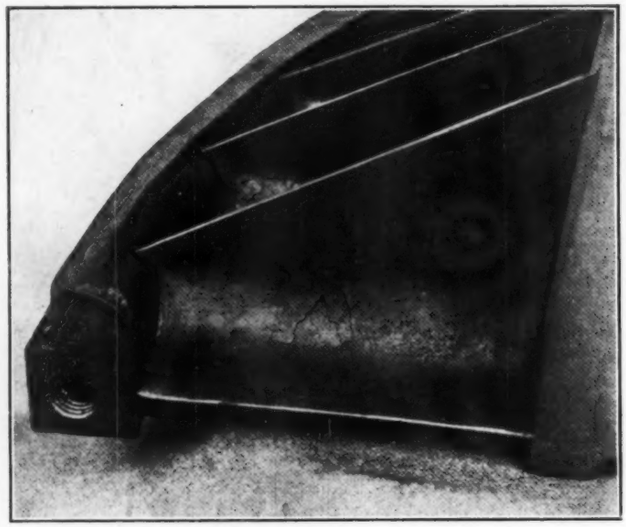


Fig. 19.

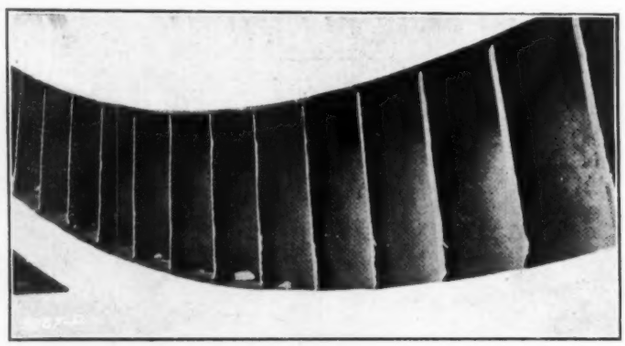


Fig. 20.

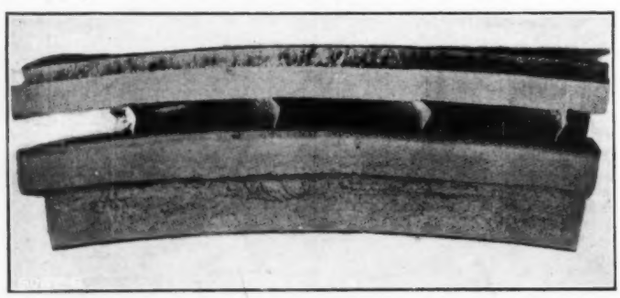
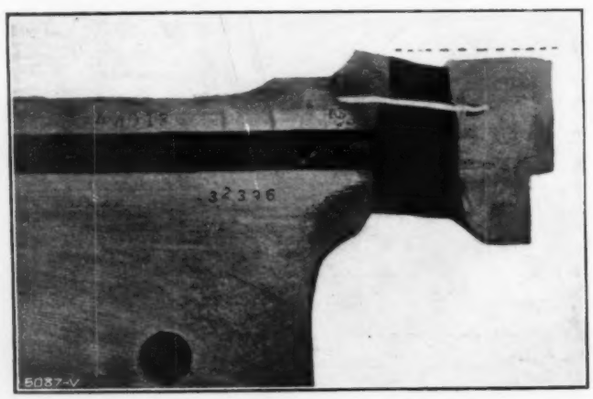


Fig. 23.



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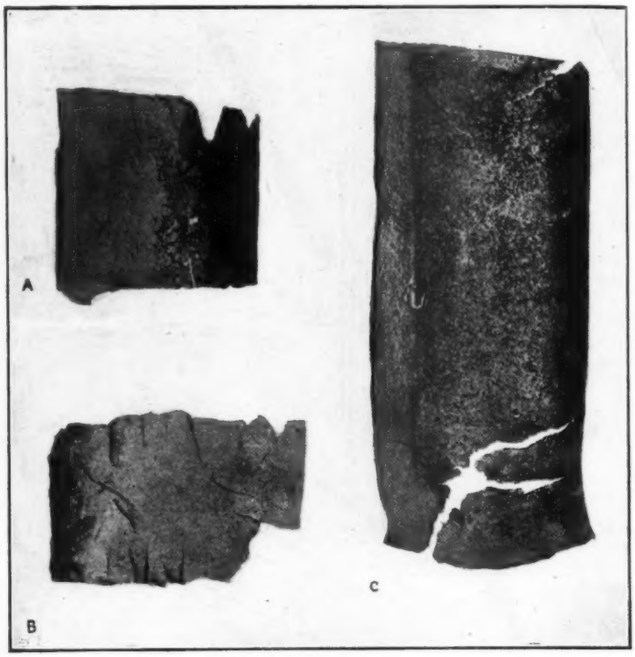

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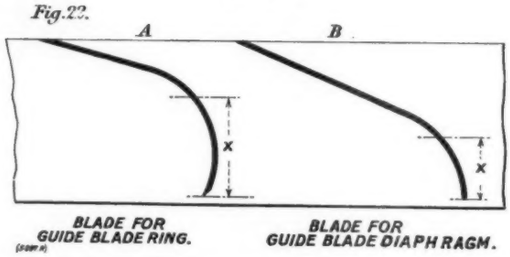
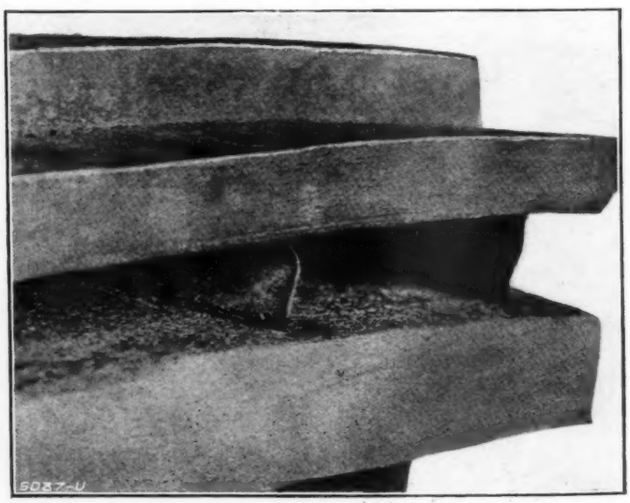
Fig.22.





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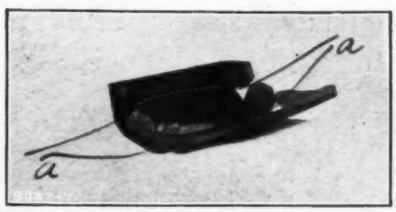

Fig. 26.

(*To face page* 443.)

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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For the United Kingdom	£2	4	6
For Canada—			
Thin paper copies	£2	0	6
Thick ,, ...	£2	5	0
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Thin paper copies	£2	5	0
Thick ,, ...	£2	9	6

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All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "Union of London and Smith's Bank, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford-street, Strand, W.C. 2.

Offices for Publication and Advertisements, 35 and 36, Bedford-street, Strand, London, W.C. 2.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.
TELEPHONE NUMBERS—3663 and 8596 GERRARD.

CONTENTS.

	PAGE
"Ground Ice" and Water Supplies (*Illus.*)	441
American Wooden Sailing Ships with Auxiliary Motors (*Illus.*)	442
The Iron and Steel Institute	443
Cementation by Gas under Pressure (*Illus.*)	446
Notes from the North	450
Notes from South Yorkshire	451
Notes from Cleveland and the Northern Counties ...	451
Notes from the South-West	451
The Scarcity of Mechanics	453
Patentees and the Prolongation of Patents.....	454
Trade Card Exemptions ...	454
The Electrical Properties of Gases (*Illus.*).....	455
Notes	456
Literature	457
Books Received	457
Industrial Notes	458
The late Mr. Harry Rigby	459
"Spontaneous Fracture of Brass"	459
Imperial Preference in Trade	459
Horizontal Multiple Drilling Machine (*Illus.*)	460
The Deterioration of Turbine Blading (*Illus.*)	461
Colonial and Foreign Engineering Projects	462

With One One-Page Plate of "GROUND ICE" AT THE GREENOCK WATERWORKS, One One-Page Plate of the DETERIORATION OF TURBINE BLADING, and One Two-Page Plate of AMERICAN WOODEN SAILING SHIPS WITH AUXILIARY MOTORS.

NOTICES OF MEETINGS.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, May 11, at 7.30 p.m., at 39, Victoria Street, Westminster, W.C. Mr. F. D. Napier on "Works Records."

THE ILLUMINATING ENGINEERING SOCIETY.—Tuesday, May 15, at 5 p.m., at the Royal Society of Arts, John Street, Adelphi, London. Discussion on "Economies in Lighting in Relation to Fuel Saving." Annual meeting at 4.30 p.m.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.—Tuesday, May 15, at 8 p.m., at the House of the Royal Society of Arts, John Street, Adelphi, W.C. 2. The following paper will be read:—"The Estimation of Toluene in Crude Petroleum," by Mr. Stanley Edward Bowrey, B.Sc. (Lond.). The chair will be taken by the President, Mr. Charles Greenway.

THE ROYAL SOCIETY OF ARTS.—Wednesday, May 16, at 4.30 p.m. Ordinary meeting.—"The Blind Sufferers from the War and their Future Employment," by Sir C. Arthur Pearson, Bart., Chairman, Blinded Soldiers and Sailors' Care Committee. Thursday, May 17, at 4.30 p.m. Indian Section.—"The Development of Banking and Thrift in India," by Mr. A. C. Chatterjee, I.C.S., United Provinces. The Right Hon. Lord Carmichael, G.C.S.I., G.C.I.E., K.C.M.G., late Governor of Bengal, will preside.

THE AERONAUTICAL SOCIETY OF GREAT BRITAIN.—Wednesday, May 16, at the Royal Society of Arts, John Street, Adelphi, London. Mr. L. Coatalen, A.F.Ae.S., will give a lecture on "Aero Engines." The chair will be taken at 8 p.m. by Dr. Dugald Clerk, D.Sc., F.R.S. There will be a discussion after the lecture.

THE ROYAL METEOROLOGICAL SOCIETY.—Wednesday, May 16, at 5 p.m., at 70, Victoria Street, Westminster. Paper to be read:—"Report on the Phenological Observations for 1916," by Mr. J. E. Clark, B.Sc., and Mr. H. B. Adames.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, May 18, at 5.30 p.m. A discourse will be delivered by Professor Frederick Soddy, M.A., F.R.S. The subject is "The Complexity of the Chemical Elements." Afternoon lectures next week at 3 p.m. Tuesday, May 15. Professor D'Arcy W. Thompson, C.B., D.Litt., F.R.S., Professor of Natural History, Dundee, on "Architectural Design in Organisms—the Laws of Growth and Form" (Lecture I). Thursday, May 17. Professor William Bateson, M.A., D.Sc., F.R.S., on "The Chromosome Theory of Heredity and the Alternatives" (Lecture I). Saturday, May 19. Professor Sir J. J. Thomson, O.M., LL.D., D.Sc., Pres.R.S., Professor of Natural Philosophy, Royal Institution, on "The Electrical Properties of Gases" (Lecture III).

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, May 18, at 6 p.m., at the Institution of Civil Engineers, Great George Street, Westminster. Paper:—"The Construction of Turbine Pumps," by Mr. A. E. L. Chorlton, Member, of Lincoln.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

NOTICE.

Owing to the recent Government restrictions, and to the enormous increase in the price of paper occasioned thereby, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal from 6d. to 8d. per copy. This increase dated from and included the issue of Friday, March 16. The change will not apply to unexpired subscriptions.

ENGINEERING.

FRIDAY, MAY 11, 1917.

THE SCARCITY OF MECHANICS.

THE deficient supply of skilled men is acutely realised and is exercising the minds of all who employ mechanics. Actually the scarcity of good men is part of the larger problem known as the industrial system; which latterly has been criticised, mostly in an adverse sense, by numerous writers and speakers. Good mechanics are rare—they never have been plentiful—and such rarity is increasing; reasons for the scarcity are numerous, but a rational solution or remedy is difficult to prescribe. The question is universal, since in a more or less acute form it is present in every manufacturing country.

A man having the mentality, dexterity and character taken for granted or implied in the term skilled mechanic, or competent all-round craftsman, is *prima facie* a competent individual in a much wider manner than in a purely trade sense. It may be said, without fear of contradiction, that a capable mechanic is at least the equal in most respects of 95 per cent. of the population. The craftsman is the backbone of all industry, and the interest to be found in the origination of mechanism and mechanical products has probably no parallel except, perhaps, in those occupations distinguished as artistic. Natural aptitude, large mentality, resource, initiative, grit, character—all matters which make a man worthy of respect—are the inalienable possession of the man who becomes an expert mechanic.

The engineering trades are truly democratic in spirit—few industries produce more able critics from the ranks. The difference between the man at the bench and those who supervise his product is one of degree, not of kind. Such difference is not great, nor is it fundamental. The leaven of the metal-working industries is the skilled man—it has been the mechanic who has placed engineering effort in its present position in the community.

There is one matter for congratulation in the existing conditions. Good mechanics were never plentiful, but present-day conditions have separated all men into two classes, those having skill and those without. Consequently, there has been a remarkable appreciation in value, the intrinsic worth of real skill has never been so realised as now. It is contended that unless steps are taken to enable men to acquire real skill invention will be paralysed, improvement and progress strangled, national industry will be forfeited, and some time or other will have to be rebuilt upon its old foundations. The unprecedented expansion of the last 2½ years has already made the value of those who understand the practical side of industry, who have special aptitude, experience and training, to become apparent even to the man in the street unable truly to assess values. This is to the good for the future. It has been commonplace to regard the workman as a person of little social importance. This unwarranted criticism and view is rapidly passing away, and the change in attitude is welcome. Due to newspaper publicity, the general tone is changing—men who appreciate one ten-thousandth of an inch and make possible the mechanical side of war have been duly advertised. There will now be no excuse for the former point of view toward the skilled mechanic on the part of the general public. They always knew they were as much set apart for special ends as the doctor, lawyer or preacher, but the notice now focused on them, to the exclusion of the rest, is in part an apology for neglect of their interests.

The trade status of the engineer workman having changed there is a possibility that the career which starts at the bench may become popular enough to attract the desirable candidate. Unfortunately the opportunity of becoming skilled is getting more limited every year. It is too little realised that the aspirant for engineering honours can make a much worse start than at the bottom. So long as there remains opportunity to become a real craftsman there exists pleasure in manual dexterity. In former days, when the trade was more limited, it was also more exclusive, only those having special aptitude would be willing to put up with the onerous conditions prevailing. It led, however, to the survival of the fittest, and these were in deed and fact exceptional and could be trusted to play their part almost anywhere.

Modern methods of specialisation have created an unadaptable industrial population, and the trade is rapidly breeding inferior labour, yet wonder is expressed at the scarcity of mechanics. In any other sphere the eugenic law as to descent would possibly be appreciated. How can we have mechanics unless we deliberately set out to produce them. Modern tendency is to commit industrial suicide. There are two outputs going on simultaneously from any business, products and men; the former earns profits, the latter serve a national as well as an industrial end. Plant can be extemporised more rapidly than skill, but if the result is to materially reduce the production of skilled craftsmen, then the industry must ultimately be penalised.

Academic training alone is no substitute, since it cannot produce the practical man of experience nor can it give manual dexterity of a high order. If the industry takes no steps to foster one of the most inherent of human desires—skill in the use of tools—it is going to decay and not to progress. Moreover, the nation which does not produce skilled craftsmen is going to forefeit industrial pre-eminence. American industry is heavily in debt to imported mechanics who emigrated fully trained, these were the men who have made her a manufacturing nation. In too many cases it is to be feared they left the country of their birth because, owing to prevailing conditions, there was little real

chance to climb higher. Such transference of energy is a national loss to their mother country, which loses citizens whose value is difficult to assess. By taking no thought for the morrow and letting the immediate present suffice, industry will forfeit its most active element from the ranks, from which nearly all that has been vital in engineering progress has come.

It would be invidious to catalogue, but two names cannot be overlooked—James Watt and the Wright brothers—the first made possible the industrial revolution, the second solved the greatest mechanical conquest man has yet made. We owe aviation not so much to specialist scientific research, as to the effort of two mechanics impelled by an idea. Reduction of scientific discovery to practical ends is one of the most vital functions of the skilled mechanic, if he is discarded the connecting link in the chain of events will be lacking.

If reward were all equal, there are thousands of skilled mechanics occupying superior positions who would gladly exchange, providing always that present conditions of work were revised and the hours shortened. There is a fascination about manual work which may be difficult to explain, but while there is less money there is more independence at the bench than in many other more envied situations. It is not unusual to find that although conditions are harder and resources more scanty, a good mechanic will prefer to work under repair conditions, or in a general and poorly equipped shop, rather than have greater comfort in a specialist plant where his latent skill is not exercised. It would, however, be lamentable if repair work alone afforded training, with tool-making the only alternative.

Natural aptitude and preservation of their skill lead many mechanics to places where these are of greater moment and more needed, though the wages paid are not greater and by absence of piece-work may be less. The same conscious pride of craft makes many first-class men gravitate to tool-making. The simple operator may make more in a week, but there are few tool-makers who would change. No qualified man is going to settle down where the work is made too easy; he is as proud of his ability as anyone else, and such pride is a lawful and desirable possession.

That the investment in real skill is justified by results will not be controverted by those (and they are numerous) who from their beginning at the bench have risen to superior positions in the world of mechanical things. The existing scarcity may serve to make the resultant proportion larger than ever, while the fact remains that opportunity to acquire the desired end is getting more limited, a condition of affairs necessitating a remedy.

PATENTEES AND THE PROLONGATION OF PATENTS.

LETTERS patent for an invention are a monopoly which, by Common Law and by section 6 of the Statute of Monopolies, the Crown is permitted to grant for a term of 14 years to the true and first inventor or inventors of any manner of new manufacture within this realm, which others at the time of granting such monopoly do not use. The grant of Letters Patent, therefore, vests in an individual the exclusive privilege of making, using, exercising and vending an invention and curtails the *prima facie* right of the public, for it excludes the public from using that invention even though they should, quite independently of the information contained in the patentee's specification, make it for themselves. In equity the public should receive some consideration in return for the curtailment of their rights which the patent thus effects, and the consideration which the patentee gives to the public is a knowledge of the invention which they are at liberty to use freely after the expiration of the patent term. A patent may, therefore, be considered as, in effect, a bargain made by the Crown on behalf of the public on the one hand and the patentee on the other hand, according to which the patentee discloses the means of putting the invention into practice for the benefit of the public, so that after the expiration of the term for which the monopoly is granted all may alike enjoy the benefits of the discovery and use it freely.

As we have shown, a patent is a bargain between the Crown and the inventor, giving the latter a monopoly for 14 years as a reward to promote the disclosure of the invention in order that the public may have the benefit of it hereafter. The inventor is not rewarded purely out of regard for his personal merit, but because the promotion of invention directly tends to be of great political and economic usefulness.

The war and the conditions of affairs arising therefrom have raised problems, and one of the problems so raised has a very strong bearing upon the interests of inventors and those owning and controlling British patents. Parliament in its wisdom has given large and autocratic powers to the Government, and the Government, in pursuance of the powers so granted, has taken over the control of many manufacturing establishments in this country. The number of establishments so controlled at the present time reaches many thousands, and it is obvious that such control has had a great effect on the manufactures and the output of the country. Many of the controlled establishments were engaged in manufacturing and exploiting numerous inventions for which Letters Patent had been granted. The control exercised over such establishments has, in many cases, necessitated the abandonment of the manufacture for which the works were designed and intended and the taking up of the manufacture of what are called "munitions." Consequently the war has prevented many inventors from having and enjoying the whole profit and advantage of their inventions; their patents have in effect been suspended and their monopoly terms have been shortened. These results are due to direct Government intervention, and, so far as we know, there has not been any suggestion that the Crown should compensate patentees with whom it has broken its bargain. We admit that the Crown has been unable to keep faith with patentees by *force majeure*, but that is no reason why patentees should not be compensated.

Now the question is, how can the Crown compensate patentees? Compensation is clearly contemplated in Section 29 of the Patents and Designs Act, 1907, in cases where any Government Department uses an invention for the service of the Crown, and we suggest that at least the same consideration should be shown where the Crown prevents the use of a patent. It is impossible to assess the loss which a patentee has suffered in money. The compensation should take the form of an extension of the patent term, and the extension of the patent term should be for a period equalling, or greater than, that which a patentee has lost owing to the present condition of affairs or direct Government action preventing the use of his invention. Every patentee has the right, towards the conclusion of the life of his patent, to present a petition for prolongation, but the procedure governing a petition for prolongation is not suitable for those patentees who should be compensated. Such a course would put patentees to a great deal of expense; matters wholly foreign to the breach of contract of the Crown would have to be considered, and questions of subject-matter and amount of profits made gone into. Further, a petition for prolongation cannot be presented until the patent term has nearly expired, and if the question of compensation be deferred until the end of the normal life of a patent, such event would, in many cases, not take place for years, and the patentee would be penalised and have difficulties with regard to evidence, which would not necessarily be easily accessible. We therefore think that a patentee, if granted compensation in the form of an extension of the patent term, should not be worried with questions that arise in a petition for prolongation, and that he should not be compelled at such time to deal with matters that are not germane to the question of compensation. It would be much simpler to place patentees in such a position that they could make application for extension of their rights soon after the conclusion of war, when all evidence is easily available, and that patentees should have extensions as of right.

Now the question arises what procedure should be adopted if our suggestion be carried out. We are strongly of opinion that in a matter of this sort a patentee should not be compelled to go to the courts for compensation. It is well known that any procedure before the High Court of Justice is necessarily expensive, tedious and slow. The Comptroller-General of Patents, Designs and Trade Marks should, in our opinion, be given the power of granting extensions as compensation. The Comptroller has, under the Patents Act, the power to revoke a patent; he has also the power to restore a patent; why, therefore, should he not have the power to compensate a patentee and extend his patent? The Comptroller is a very busy man, and we have a suggestion to make that would lighten his work considerably. During the war we have become accustomed to placing matters before committees or tribunals. We suggest that the question of compensation to patentees should be placed in the hands of a committee, on whose report, if favourable, the Comptroller should compensate the patentee by extending his patent. A panel of leading patent barristers and patent agents could easily be formed, and from such a panel committees or tribunals could be got together to consider each individual case. The procedure would not be costly, and now that the country is accustomed to the work of committees and tribunals, we feel sure that such a procedure would meet with approval.

We have in the past made many suggestions for the improvement of our Patent Laws, and many of our suggestions have been adopted. Whether or not the proposals we now put forward be adopted, it is quite clear that inventors and the owners of British patents should take a personal interest in the question of compensation and that steps should be taken to impress on the Government the urgency of the question.

TRADE CARD EXEMPTIONS.

IT is announced that the War Cabinet have decided to replace the various methods of protection under which men of military age are at present retained on munitions and other work by a new system designed to protect the minimum number of men essential to output and to remove certain inequalities and anomalies created by the present systems. In other words, the trade card agreement is to be terminated. As explained in ENGINEERING of April 6, that agreement was made last year by the Government and the Amalgamated Society of Engineers. Ultimately 24 other craft unions became parties to it. Each of these unions was empowered to issue to its members cards of exemption from military service. Possession of a card provided absolute protection, and the Army Council issued instructions to recruiting officers that no man who produced a card should be removed from his work without specific authority from the War Office, which would not be given without reference to the executive of the man's union.

Criticism of the agreement was most pronounced, especially by trade unions which did not share the privilege of issuing trade cards; indeed, the scheme is known to have been the cause of bitter contentions between unions. Naturally the parties to the agreement were not desirous of having the trade card system terminated, and we understand that there were numerous conferences between representatives of the Government and of the trade unions before an understanding was come to. The Amalgamated Society of Engineers, as the principal union concerned, announced by telegram last week that "delegates have reached agreement with Government and arrangements have been come to in connection with the Schedule of Protected Occupations which provide adequate protection for skilled men and apprentices. Delegates urge there should be no stoppage of work."

In our former comments on this subject we expressed the opinion that the most effective scheme would be a revision of the list of scheduled occupations, with provision for releasing young men first. This is what has been arranged, except that there is a new schedule of protected occupations applicable to men employed on Admiralty, War Office or Munitions work, or in railway workshops [M.M. 130]. It contains a list of occupations or classes of workmen provisionally scheduled; the ages below which men may be called up; and the interval of time to be allowed before men who are not scheduled may

be called up. The main divisions of the schedule are as follow:—

A. Shipbuilding and repairing and marine engineering.
B. Mining and quarrying.
C. Furnace firebrick making.
D. Coke-oven plant.
E. Metal manufacture.
F. Engineering (including agricultural implement and machine making, erection, repair and maintenance of plant and machinery).
G. Instrument making.
H. Miscellaneous metal trades.
I. Building, woodworking and allied trades.
K. Chemicals, drugs, explosives, oils, rubber, &c.
L. Leather trade.
M. Textile and allied trades.
N. Miscellaneous trades and occupations.
P. Light and power undertakings.
R. Professional occupations and administrative staff.

The protection afforded by the schedule is in some cases all-embracing, *e.g.*, all classes of workmen who on March 29th last were engaged on shipbuilding, boat and barge building and repairs, and in marine engineering shops are protected. In other cases the protection applies to men of 23, 25, 27 or 30 years of age and over, according to the relative importance of the various occupations. But the present schedule is provisional. It may be modified later if the Army's need is again so urgent that a further release of men from the manufacture of munitions is found necessary, or if experience shows that the operations now performed by men protected under the schedule can be undertaken by men not required for the army or by women. Moreover, protection applies so long only as a man is engaged on Admiralty, War Office or Munitions work, or in railway workshops. There is also the further qualification that "the national need at the present moment does not permit of the retention in such work of any man of military age who does not devote his whole time and energies to it."

Employers of labour have been asked by the Ministry of Munitions for a return of all male employees who on January 1st last were over 16 years of age and are still being employed, together with the totals of women and boys employed. The return, for which a special form is provided, is to show each man's grade classification under the schedule. Here is obviously much room for differences of opinion. The Government proposes to invite the assistance of representatives of labour in deciding cases in which the status of a man under the schedule is doubtful. For this purpose the Enlistment Complaints Committees will be utilised.

The lists of employees, marked to indicate the men for whom protection is desired by the employer, are to be sent to a new official—the Munitions Area Dilution Officer, whose office will be known as the Munitions Area Recruiting Office. All records concerning men in protected occupations, and all arrangements as to their release or retention, will be made in the Munitions Area Recruiting Office, to which also claims by employers or employees must be addressed. The responsibility for regulating the withdrawal of men from firms who are notified that they are classed as Admiralty or War Office firms will ultimately rest, as regards Admiralty firms, with the Admiralty representative of the district, and, as regards War Office firms, with the Director of Army Contracts or his local representative. Men who are not passed fit for general service (military medical category A) will not for the present be recruited, unless their record for absence from work is bad.

A card to serve as a protection from recruitment, known as a scheduled occupation certificate, will be issued by the Munitions Area Recruiting Office to every man entitled to protection under the schedule. Men of military age who are not in an occupation covered by the schedule will also be supplied with a card should it not be intended to release them for military service.

An essential part of the scheme is the provision of substitutes, for which purpose the National Service Department will render assistance, a representative of that Department being attached to the Munitions Area Recruiting Office. Employers are invited to indicate the men for whom substitutes are required, and effort will be made to supply them. But they are informed that the need of the Army for men is too urgent to admit of the release of men being delayed in every case until substitutes have been provided, especially as the supply of male substitutes is likely to prove unequal to the demand. Employers are, therefore, urged to make every effort to fill the gaps, by employing women on all work which they are able to do and by transfer or rearrangement of labour within the works.

Men who are released from Admiralty, War Office or munitions work, or from railway workshops, will be posted to line regiments if they do not possess the qualifications required for the technical units in the Army, or if there is no demand for them in any technical unit. Men released are to be called up in age groups, commencing with the younger men, thereby removing any ground for complaints of victimisation.

Such is the scheme. Whether it will work smoothly or, indeed, at all must rest very largely with the trade unions. That some of them should resent the withdrawal of the trade card scheme is inevitable, but they cannot deny the necessity for so doing. Men are urgently needed for the Army, and there is no doubt that they are to be obtained from the ranks of craftsmen. The essential thing was that the younger men should be first taken, and this is secured by the new schedule of protected occupations.

THE ELECTRICAL PROPERTIES OF GASES.

On Saturday last Sir J. J. Thomson, O.M., P.R.S., delivered the first lecture of his annual course at the Royal Institution. These lectures have in previous years been given during the winter months; but owing to conditions due to the war they have had on this occasion to be postponed till after Easter.

In opening his lecture Sir Joseph Thomson said that if the measure of the importance of a scientific subject lay in its power to come to close quarters with the fundamental bases of physics and chemistry, then the subject he had chosen for his course had strong claims to be counted as one of the most important in the whole range of physics. He would justify this claim by anticipating a little certain results, to be established later on. Two of the most fundamental questions of physics were: what was the nature of electricity? and what was the structure of matter? Now the study of the discharge of electricity through gases was responsible for the view now taken as to the nature of electricity. We now knew that electricity was, so to speak, atomic in structure, that every charge of electricity was made up of an immense number of smaller unit charges, and we differentiated sharply between positive and negative electricity. We knew that the atoms of negative electricity were extremely minute, having a mass less than anything else known up till a few years ago. They had, moreover, the power of moving with velocities which fell but a small percentage below those of light. The positive units were much more massive, having 1,700 times more mass than the negative particles. This view had been arrived at by the study of the electric properties of gases.

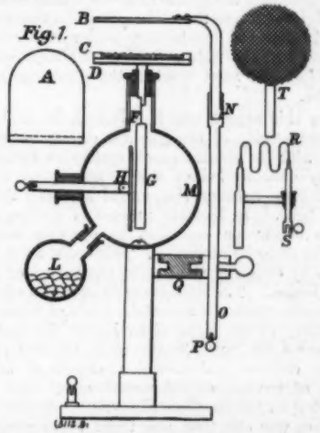
As for the other problem, concerning the structure of matter, the same study had shown that beyond the chemical atoms which made up the mass of ordinary bodies still smaller systems existed, each chemical atom being a little universe comprising many planets and suns. We knew that some of these atomic constituents were particles of negative electricity and we could count the number in any atom. In addition to these very small negative particles there was an equivalent amount of positive electricity. Moreover, by methods which the electrical properties of gases put at our service we could determine the magnitude of the systems inside the atom with an accuracy approaching that with which we could measure the size of ordinary bodies.

The study of the discharge of electricity through gases would, the speaker, proceeded, enable us to investigate problems of the greatest interest to the chemist. We wanted to know whether all the atoms of what chemistry recognised as elements were of the same kind. The evidence was that two atoms might show the same chemical properties and yet not be identical. One might, in fact, be more massive than the other. Since, however, the chemical properties were identical, it was impossible to separate the two by any chemical process. Hence in ordinary determinations of atomic weights we were not able to say whether we were dealing with anything but a mixture of two kinds of atom, although the weight of the one might not be the same as that of the other. The numbers given for the atomic weights might thus be vitiated by the fact that though similar in chemical properties the two were not identical as to mass. A sort of mean of the two atomic weights would thus be obtained.

An important question, raised long ago by Prout, was whether all the atomic weights were multiples of that of hydrogen. In the course of these lectures reason would be shown for believing that Prout was not very far wrong, after all, if we gave a wider interpretation to what he meant by the hydrogen atom. It was of course impossible to maintain this if the experiments on atomic weights were interpreted in the most straightforward way. The values found were certainly not integral multiples of the atomic weight of hydrogen. If, however, two atoms, chemically indistinguishable, had atomic weights of 2 and 3 respectively, a mixture of them might give an apparent atomic weight of anything whatever between the numbers 2 and 3. Yet, nevertheless, the mixture would consist of units each an integral multiple of the mass of the hydrogen atom. It seemed possible, though in these strenuous times opportunity for proof had been lacking, that by a study of the electrical properties of gases new light might be thrown on this question of atomic weights.

In the foregoing he had, he hoped, said enough to justify the importance of his subject, and he would now show a few experiments. The first was perhaps hardly an experiment at all, but merely a matter of common observation, viz., the extreme difficulty of getting a gas to have anything to do with electricity so long as the gas was in its ordinary condition. To this end he would use the electroscope represented in Fig. 1. The essential parts

Fig. 1.



were the plate H and the gold leaf G set edgewise to it and connected to the top plate D. If a charge was given to H the gold leaf was attracted and touched H, and then was immediately repelled. So long as it held the charge acquired at the contact it stayed repelled, but if there was leakage from the top plate D it would on losing its charge be attracted again up to H and acquire a fresh charge. Hence with a steady leak the gold leaf would be set into a state of oscillation, alternately being attracted up to H and then repelled. The rate of oscillation was a measure of the rate of leakage.

So long as the top plate was surrounded by ordinary air there was, the lecturer proceeded, no appreciable loss of charge, and the gold leaf remained away from the plate. Many, Sir Joseph proceeded, might ask why should any leakage be expected in such conditions. From the point of view of the nature of a gas its absence was, however, very remarkable. A gas consisted of a number of small particles, which were continually hitting the charged surface of the plate D and going off again. If they carried electricity with them they would act as so many little proof planes, yet in spite of the fact that the plate was struck by the

molecules of the air millions and millions of times per second there was no appreciable loss of electricity. Were these molecules able to take up a charge in the same way as a proof plane of the same size, the top plate would lose every vestige of its charge in $\frac{1}{500,000,000}$ of a second. Hence the retention of the charge was really much more wonderful than actual observation would induce us to believe.

The lecturer next showed that there was still no loss of charge when the plate was heated and ether poured over it. The ether evaporated off but left the charge behind it. The vapour, in fact, seemed, he said, incapable of receiving a charge, or at any rate resolutely refused to do so in the conditions of the experiment. This experiment had, Sir Joseph continued, been carried to a much greater pitch of accuracy. In some experiments the ether had been replaced by mercury, and the mercury evaporated off. The vapour still remained uncharged, although it was the vapour of a metal and came from a charged metallic surface.

This experiment showed, Professor Thomson continued, one aspect of the behaviour of gases to electricity. If, however, a gas were subjected to suitable treatment, then it was quite ready to take up a charge and to conduct electricity. There were various ways of achieving this end. It was, for example, sufficient to expose the gas to the radiation from a radio-active body. The lecturer showed this by directing on to the plate D of the electroscope a blast from a metal pipe at the entrance to which a little radium had been placed. A rapid leakage of electricity was thereby established, as shown by the vibrations of the gold leaf. This proved, he said, that not only was it possible by proper treatment to put a gas into a condition in which it conducted electricity, but that it retained this condition for at least the time taken for it to pass down the tube. He next varied the experiment by connecting the outer wall of the tube to one pole of a battery, and a wire strung along the axis of the tube to the other pole. In this case he showed that the conducting power conferred by the action of the radium had been almost entirely lost before the blast reached the discharge end of the tube.

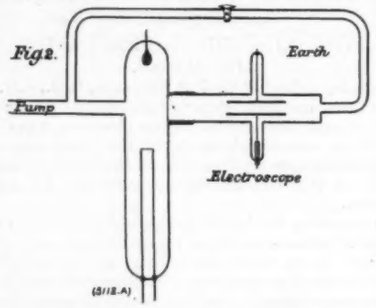
From this experiment it followed, he said, that the conductivity of the gas was due to something mixed with it which was charged with electricity, as only charged bodies would be moved by the electric force between the central wire and the wall of the tube. In fact the process of making a gas into a conductor consisted in ejecting negative particles from its molecules. This could be done, as shown, by exposing the gas to the action of radio-active bodies. The Röntgen rays were also effective, as was also exposure to certain kinds of light. The peculiarity of the light effect lay in the fact that for success the wave-length must be less than a certain definite value which depended on the nature of the gas experimented with. Only light belonging to the extreme ultra-violet section of the spectrum was effective, and there was a sharp line of demarcation between the effective and ineffective portions of the spectrum. Red light, even if concentrated by lenses till it was able to set things on fire, had no effect, whilst success was easily attained with ultra-violet light of quite feeble intensity.

Radiation of still smaller wave-length was, the lecturer said, also effective. This was shown by the apparatus represented in Fig. 2. On the right of this is shown a horizontal tube containing one plate connected to earth and an opposing plate coupled up to a charged electroscope. Any current between these plates will cause the gold leaf of the electroscope to oscillate. The end of this horizontal tube where it enters the vertical tube is covered gastight by a film of celluloid, so thin that it shows the colours of the soap bubble. The vertical tube is a special form of cathode ray tube, and on establishing a discharge between the upper and lower electrodes the lecturer showed that there was a current between the two plates in the right-hand horizontal tube, as was indicated by the motion of the gold leaf of the electroscope. The cathode discharge, he said, gave rise to radiations which passed through the celluloid window and rendered conductive the gas beyond it.

He had already, Sir Joseph continued, shown that ordinary air was an extremely good insulator. When, however, the test was made with the greatest delicacy and care, it was found that air did not definitely refuse to conduct, but would convey a little electricity. This remnant of conductivity was far too small to be shown in a lecture experiment, but had nevertheless given rise to an immense amount of work in every country and under every conceivable condition. The problem was to find what this residual conductivity was due to. The most natural view was to attribute it to the radium in the earth scattered through the rocks and soils.

The conductivity of a gas, he went on, arose from the ejection of negative particles from the molecules. This residual conductivity of ordinary air showed that about eight molecules were thus affected per cubic centimetre per second. Since one cubic centimetre contained 2.75×10^{19} molecules, and only eight became conductors per second, it followed that if any particular molecule "wanted" to be split up, it might have to wait ten-million-million years before its time came. It was this extremely small effect which had given so much trouble, and occasioned such

Fig 2.



heart-burnings and discussions in scientific societies throughout the world. As stated, it might be due to the radium in the soil, and accordingly tests had been made with vessels in ordinary rooms, or sunk ten to twelve feet below the surface of a pond; in the middle of the Atlantic, and over the ice covering frozen lakes. In all cases this residual conductivity remained. The idea arose that it might be intrinsic to the air itself—that some of the molecules split up spontaneously like those of radio-active bodies. Just before the war, however, McLellan, of Toronto, taking advantage of the climatic conditions, replaced the zinc vessel commonly used in the experiments with one constructed of ice, and found that the value of the conductivity was reduced to one-quarter of what it was when zinc vessels were used. It was now thought, therefore, that the effect was due to some trace of radio-activity in the zinc, either on the part of the metal itself, or of some impurity in it. The question had, the lecturer said, given more trouble than some of the most celebrated problems in the history of physics.

The nature of the conductivity of gases was, Sir Joseph continued, at one time much misunderstood. With any ordinary conductor, if the length were increased the resultant current was enfeebled. This result was so familiar as to seem a truism. With gases, however, just the opposite happened. The thinner the layer of gas across which conduction occurred the less the current, and in fact the conductivity was only appreciable when the thickness of the layer was substantial. This peculiarity was at the outset misunderstood. It arose from the fact that when a gas was rendered conductive by, say radium, every ion generated was made use of. By doubling the thickness twice as many were produced, and the greater the number of these particles the greater the rate of leakage, provided always that the force between the plates was sufficient to make all come up to the plates in the time available.

NOTES.

ALCOHOL FROM ACETYLENE.

THEORETICALLY the preparation of alcohol from acetylene looks easy. By hydrogenation the acetylene C_2H_2 can be converted into ethylene, C_2H_4, which is transformed into ethyl sulphonic acid by means of sulphuric acid; hydrolysis then transforms the sulphonic acid into ethyl alcohol, C_2H_5OH. But neither this direct way, nor various indirect processes, appeared for a time to prove technically profitable, and so the manufacture of alcohol from calcium carbide, which, treated with water, yields acetylene, seemed to remain a problem. Within the last few years, however, several of the large German chemical works have taken patents on the preparation from acetylene, by means of acid mercury salts, of aldehydes, which differ from their alcohols by a deficiency of two atoms of hydrogen. Whether and how far the preparation and hydrogenation of these aldehydes is at present being utilised in Germany we do not know. But the alcohol department of the Swiss Government has lately—in March—granted a concession for the manufacture of 7,000 tons of alcohol (more later) per year from calcium carbide to the Elektrizitätswerk Lonza, A.G., of Gampel (in the Rhône valley) and Basle, Switzerland. The works are to be opened within 18 months, and are to supply at least 2,500 tons of alcohol to the Government. The Lonza works are situated on the Lonza, one of the rivulets which come from the Lötsch glacier; the main river is the Lötsch, which, flowing southward, joins the Rhône at Gampel, on the right bank between Sion and Brig in the Canton Wallis (Le Valais). The construction of the Lötschberg Electric Railway, which ends at Brig and joins on to the Simplon Railway, has drawn public attention to this district. The new alcohol works are to be erected at Visp, some miles up the Rhône, east of Gampel. The process of the Lonza Company consists in passing vapours of acetaldehyde, CH_3COH, mixed with an excess of hydrogen, over finely-divided nickel (catalyst); water and alcohol, $CH_3 . CH_2OH$, are formed; the former is frozen out, and the excess of hydrogen gas reacts again with aldehyde vapour. The Swiss patent on which the process is based is not yet available over here.

BALL BEARINGS.

The remarkable success of the ball bearing is one of the outstanding mysteries of applied mechanics, since the device violates a number of the accepted maxims of the art, in particular the late Professor Sweet's precept that parts liable to wear should be designed so that they cannot wear out of shape, in which case they would not, he maintained, wear much. The extraordinary carrying power and endurance actually realised are a standing tribute to the care in construction and judgment in selection of the materials shown by the manufacturers. Failures, few though they be in comparison with the number of bearings at work, are, of course, not unknown, and these failures formed the subject of a paper recently read before the Birmingham section of the Junior Institution of Engineers by Mr. G. F. Barrett, of the Hoffmann Manufacturing Company, Limited. Mr. Barrett observes that whilst ball bearing makers heard at once of any failure, nothing is said to them when the bearings prove satisfactory, and hence in fixing the loads at which their bearings are rated makers are commonly much more conservative than users. The load-carrying capacity of the bearings depends on the number and size of the balls. The latter should be as large as possible, but is limited by the thickness necessary for the races. These must be stout enough to be safe from distortion by an outer housing not quite true, and from bursting if forced on to a shaft. The races must, moreover, be sufficiently heavy to be hardened without fear of cracking. These races are, Mr. Barrett states, best made of mild steel, as greater hardness can be obtained by carburising this than in any other way. A reasonably strong cage is necessary to retain the balls, as though a light cage suffices if the bearing is merely running under a steady load, it will not prevent bunching under shocks and jars. Some makers use a cage only $\frac{1}{10}$ the ball diameter in thickness, whilst with others the thickness is one-third the ball diameter. The curvature of the races should be but little less than that of the ball. The excess of the race radius may be as little as 5 per cent., though with some makers the radius of the race is 20 per cent. greater than that of the balls. A ball bearing differs from a plain bearing in the absence of the film of oil, which is capable, under sudden shocks, of acting as a buffer between the opposing surfaces. With ball bearings there is

always actual metallic contact, and the stress developed at this point under a shock must be very great. In fact a weight of 4 oz. falling on to a ball from a height of 10 in. is sufficient to produce a permanent distortion of half a mil. Nevertheless balls of this size are often used in bearings carrying loads of 15 cwt. The carrying power of a ball is commonly considered to vary as the square of its diameter, but Mr. Barrett says that experience shows that in practice large balls carry less than this rule would indicate, and suggests that the working load should be taken as proportional to the seven-fourth power of the diameter. In practice the conditions of use vary greatly, so that actual experience has to be relied upon to show the actual carrying power. Where mounted in light non-rigid housings, as in motor-car work, a lower factor of safety can be used than where ball bearings are used, say, for electric motor spindles. Here the ball race is fitted adjacent to a heavy rotor and in a very rigid cast-iron housing. In fact Mr. Barrett states ball bearings do not stand up at all well in the larger electric machines, and trouble has been met with even with those of more moderate size notwithstanding the adoption of a large factor of safety. For this work roller bearings are much more suitable. In aeroplane work a long life is not expected, and weights must be kept down, so that relatively small bearings are used. A valuable addendum to the paper is a list of suitable sizes of bearings both for light and heavy motor vehicles, based on the practice of the best English makers.

EULER'S COLUMN FORMULA.

In a recent issue of *The Physical Review* Mr. R. W. Burgess states that there is an error in the method usually adopted for deriving Euler's formula for the strength of a column. The equation to the elastic curve is generally written as

$$P y = \frac{E I}{\rho}, = E I . \frac{\frac{d^2 y}{d x^2}}{1 + \left(\frac{d y}{d x}\right)^2},$$

Here P denotes the thrust on the column and y its deflection. It is then assumed that the term $\left(\frac{d y}{d x}\right)^2$ can be neglected, and the equation for the deflection is then obtained in the form

$$y = h \cos \frac{x}{a},$$

whence

$$a = \sqrt{\frac{E I}{P}}.$$

For small deflections the values thus found are, Mr. Burgess states, just one-half the proper values found by retaining the term $\left(\frac{d y}{d x}\right)^2$. Putting $\frac{d y}{d x} = p$, he writes the complete equation in the form

$$\frac{2 a^2 p \frac{d p}{d y}}{(1 + p^2)^{\frac{3}{2}}} = -2 y,$$

which on integration gives

$$\frac{2 a^2}{(1 + p^2)^{\frac{1}{2}}} = y^2 - h^2 + 2 a^2,$$

or

$$p^2 = \frac{4 a^4}{(y^2 - h^2 + 2 a^2)^2} - 1.$$

The length of the axis of the column between $y = h$ and $y = 0$ is then

$$\int_h^0 \sqrt{1 + \left(\frac{d x}{d y}\right)^2} d y = \int_h^0 \frac{\sqrt{1 + p^2}}{p} d y,$$

which by substituting the value just found for p can be expressed as an elliptic integral. The length of the column corresponding to a given value of h is by the true formula given by

$$l = \pi a \left(1 + \frac{h^2}{16 a^2} + \&c.\right),$$

and by the approximate formula

$$l = \pi a \left(1 + \frac{1}{4} \frac{h^2}{a^2} + \&c.\right)$$

The shortening of a column due to a given deflection is thus incorrectly given by the usual formula.

LITERATURE.

Graphics and Structural Design. By H. D. HESS, M.E., Professor of Machine Design, Sibley College, Cornell University. Formerly Designer and Computer for the Mechanical Department of the Pencoyd Iron Works and the American Bridge Company. Member of the American Society of Mechanical Engineers. Second Edition. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. 1915. pp. 436. [Price 12*s.* 6*d.* net.]

THIS is a book prepared more particularly for the use of students, but intended also to be of assistance in practical design. The title does not fully indicate the scope of its contents, as the methods used are not wholly, or even chiefly, graphical. It deals with the design of many differing classes of structures, some not usually found in text-books.

Beginning with a short chapter on materials, the major portion of which is, however, taken up with extraneous matters presuming a considerable antecedent knowledge on the reader's part, the author proceeds in chapters following to expound the essential methods of graphic determination. The treatment of deflection curves is usefully extended to include the case of continuous beams. Many instructive cases of wind load on roof trusses are considered, from which the writer proceeds to the algebraic examination of ordinary roof and bridge trusses. This is followed by a chapter on influence lines, a method of the greatest use when applied to rolling load effects. Columns are well considered, and long beams having no lateral support are dealt with, though somewhat cursorily.

Having devoted about 100 pages to the above-mentioned matters the author proceeds to consider questions of design arising in special structures, as, for instance, girders for conveyors. Such girders are commonly very light, and for that reason need the most careful attention, as weak points in design are more likely to cause trouble than is the case with heavier work of stiffer sections.

The estimating of stresses in bents or towers to carry pipes and cables is dealt with somewhat fully, particularly with respect to the effects of temperature changes. Design of a steel mill building and of a railway plate-girder bridge is considered in detail, though in the latter case the author avoids all reference to the method to be adopted in determining the web thickness, and with respect to intermediate stiffeners simply says they are not usually calculated. It is a candid confession—substantially true—but some indication of conditions to be satisfied might with advantage have been introduced. The design of plate web stiffeners is not indeed so hopeless a matter as it is sometimes made to appear.

Two well-selected examples of crane frames are fully calculated, and girders for a travelling crane worked out in detail, including the effects of retardation in setting up lateral bending moments.

The author, in estimating moments of inertia of the girder sections, adopts the usual procedure, giving this quantity for the net section, holes being deducted. There is involved in this method a fundamental though not serious error. That which determines stress in such a section, at the holes, is rather the stress correspondent to the moment of inertia of the contiguous unholed section of the girder, which stress is amplified by loss of section at the holes. The stress so resulting may, it becomes evident, be materially different from that ascertained by the method usually adopted. In the particular case considered the difference is small and in a safe direction, though in other cases the error may be material and give an exaggerated value.

A chapter is devoted to reinforced concrete, the formulæ in common use being developed from the usual premises. An empiric expression for deflection—due to G. A. Maney—is presented, which may be of use, though it seems to give results somewhat in excess. In this connection it is to be remarked that the flexure of reinforced concrete beams is commonly small, and cannot be arrived at having regard only to the stresses considered in estimates of strength. Any such beam is, according to usual practice, designed on one basis, but behaves in a manner regardless of hypothesis. The stresses in tension steel may be developed in full at any section of the beam, but commonly are not, tension steel and concrete acting together as compression steel and concrete are assumed to act. For practical purposes the deflection of such a beam may be deduced either by such a formula as the author quotes, introducing correcting constants, or by reference to concrete stresses at the top and bottom of the beam, supposing the steel and concrete to act homogeneously throughout the beam's depth. In the design of continuous beams this matter becomes of importance. The author's treatment of reinforced concrete columns cannot be regarded as complete, the usual procedure for short columns only being advanced—this the author approves for ratios (inside steel) as great as 25 to 1—a somewhat hazardous teaching. Following some pages on foundations, the design of chimneys receives considerable attention. Retaining walls are dealt with at some length, and bins for the storage of grain, ore, coal, &c. This somewhat troublesome branch of design—troublesome chiefly on account of uncertainties of pressure distribution—is studied with respect to a considerable variety of conditions. Following chapters upon the details of shop floors, walls and roofs, calling for no remarks, the author furnishes specifications for structural steelwork, bridges and concrete work, each of which will repay examination, as representing current practice in America, and containing much useful information. The volume ends with a collection of nearly 200 well-selected problems to be worked by the industrious student, with answers by which his results may be checked.

There is much useful matter in this book, but it is treated with a want of uniformity as to the explanatory text, some quite simple questions being enlarged upon, while others, difficult or obscure, are left to be worried out by the student as best he may. Proofs are, in large measure, lacking; but it is to be remembered, as stated by the author in his preface, that the work is intended primarily as a text-book for the use of his own students, who would no doubt have advantages supplementing the information to be found between its covers.

The printing is excellent, all formulæ are well displayed—a really important matter—and the diagrams clear.

BOOKS RECEIVED.

Elementary Cams. By FRANKLIN DE RONDE FURMAN, M.E. New York: John Wiley and Sons, Inc. London: Chapman and Hall, Ltd. [Price 5*s.* 6*d.* net.]

General Chemistry. By HAMILTON P. CADY, Ph.D. London: Hill Publishing Company, Limited. [Price 9*s.* 6*d.* net.]

Hydro-Electric Power. By LAMAR LYNDON. In Two Volumes. Vol. I—*Hydraulic Development and Equipment.* Vol. II—*Electrical Equipment and Transmission.* London: Hill Publishing Company, Limited. [Price, Vol. I, 21*s.* net.; Vol. II, 15*s.* net.]

The Vaporising of Paraffin for High-Speed Motors (Electric Ignition Type). By EDWARD BUTLER, M.Inst. Mech.E. London: Charles Griffin and Co., Limited. [Price 3*s.* 6*d.* net.]

The Guide to South and East Africa, 1917 Edition, Edited annually by A. SAMLER BROWN, F.R.M.S., and G. GORDON BROWN, F.R.G.S. London: Sampson Low, Marston and Co., Limted. [Price 1*s.*]

Naval War Services of Officers of the R.N., R.N.R., R.N.A.S., R.N.V.R., and R.M., with Table of V.C. Awards and Diary of Naval Events. London: Offices of *The Royal Navy List,* 326, High Holborn. [Price 1*s.* 6*d.* net.]

Instruction Manual for "Wolseley" Aero Engines (Wolseley-Renault Types). Birmingham: Wolseley Motors, Limited. [Price 5*s.*]

The Year-Book of the Scientific and Learned Societies of Great Britain and Ireland. Thirty-third annual issue. London: Charles Griffin and Co., Limited. [Price 7*s.* 6*d.*]

Electricity and the Motor Car: Lighting—Engine Starting—Ignition. By F. H. HUTTON. Second Edition. London: Iliffe and Sons, Limited. [Price 2*s.* 6*d.* net.]

The British Corporation for the Survey and Registry of Shipping, Established 1890. *Rules of Classification and Construction.* Glasgow: The British Corporation, 12, Vincent-street. [Price: To individual firms, two guineas; to companies and associations, three guineas; additional copies, one guinea in each case.]

EPICASSIT.—Epicassit is a metal powder which is mixed with liquid and applied by a brush to steel goods. The foundation article is heated until the metal powder melts. This powder may be tin; two-thirds tin and one-third lead; one-third tin and two-thirds lead; 5 per cent. tin and 95 per cent. lead; 35 per cent. tin, 15 per cent. lead, and 50 per cent. zinc. The process originated in Germany, and in America is in the hands of Messrs. Henry Hess and Co., Philadelphia.

INDUSTRIAL NOTES.

THE following telegram was received from His Majesty by Sir Trevor Dawson as chairman of the London Association of Foremen Engineers' dinner last Saturday :—"I am commanded to express to you, the chairman and the members of the London Association of Foremen Engineers, the thanks of the King for the loyal sentiments contained in your message on the occasion of your 54th anniversary dinner. His Majesty is especially gratified by the association's declared determination to do their utmost to maintain the necessary supply of munitions, upon which the victorious issue of the war so largely depends.—STAMFORDHAM."

The chair at the function above referred to was occupied by Sir Trevor Dawson, who observed that the war had shown us what combination could do, and expressed the hope the lesson thus learned would prove fruitful on the establishment of peace. He emphasised the importance of the works foremen in securing and maintaining the efficiency of our industries. The output now attained by their aid utterly surpassed, he said, that in "another country," where the subject had been exhaustively studied for the past ten years, and where there were powers of control over labour neither held nor desired here. The redemption of the National Debt could, he said, be effected only by increased productivity. The task could be faced with confidence if all were prepared to do their part. Nothing should, he said, be done to discourage workmen to make high earnings.

We deal elsewhere with the changes which are being made in the arrangements for protecting skilled men engaged in essential occupations from recruitment for the Army. Experience has shown that the trade card system led to many inequalities. Under it there might be two men in the same shop of the same age and the same skill, and drawing the same pay, on identical work; yet one might hold a trade card and be exempted, whilst the other would be taken. In future exemption will depend not on whether a man belongs to a particular trade union, but on his age and the nature of his employment. The scheme is resented by the engineers' society, and this was, in the main, the real cause of the abandonment of work by a very large body of men engaged in the Lancashire engineering trades. The occasion was a dispute at the works of Messrs. Tweedale and Smalley, of Castleton, Rochdale, who were, to say the least, indiscreet in their methods of dealing with their hands and, as it turned out, their action was also illegal. In fact the courts have held that under present conditions it is, in certain cases, at any rate, illegal to dismiss men for breach of contract, and a firm of agricultural engineers were last year fined for dismissing a man for joining a union in contravention of his agreement with his employers. The Castleton firm have been convicted of infringing the Munitions Act by not giving their hands due notice of a change in the working conditions and by not giving an opportunity for local consultation with the workmen and their representatives.

The real difficulty of the situation in the engineering trades lies in the fact that whilst there is a general agreement that skilled work should be given to skilled men, experience has shown that much that was considered to be skilled work before the war can be done, and done better, by admittedly unskilled labour. To cut a single breech block, for example, is undoubtedly a job for a highly skilled turner, but to cut them by the score has been proved to be well within the capacity of casual woman labour. In fact, in one munitions works in this country women are turning out guns up to 4½-in. calibre complete without any skilled assistance whatever. In short, it has been demonstrated that, speaking generally, repetition work is unskilled work, on which it is socially and economically disadvantageous to employ skilled hands, who should be kept for better work and paid accordingly. Resentment at the discovery has perhaps not been unnatural, and the workmen strongly oppose the application of the principle to commercial work. In this, of course, they are shortsighted, for, as Mr. John Hodge said at the dinner of the London Association of Foremen Engineers last Saturday, restriction of output is a disastrous policy. After the war we shall need the best from every skilled man that he can give, and he cannot be spared to do monotonous repetition work, at which he cannot compete on even terms with the operative who knows how to do nothing else. In fact the Ministry announce that it is absolutely necessary to have recourse to dilution on commercial as well as on war work. The skilled men engaged on commercial work must be released to do their share on essential war work, and this will only be possible if dilution be extended also to private factories. The only alternative is to close down private factories; since the skilled men must be employed where most needed.

There is still much trouble from lost time, a number of girl munition workers being fined at Birmingham last week for losing half-hours. In another case where a girl was fined for missed time she entered the not-unreasonable plea that she could not work day in and day out, Sundays included, from 8 a.m. to 8 p.m. It appeared, however, that the Sunday work was optional, and the case was adjourned for a month, the president remarking that the more Sunday labour there was, the less would be done during the week. A great improvement in the matter of time-keeping is recorded at Sheffield. During March the tribunal had to deal with 968 cases, of which 445 were for bad time-keeping, with an aggregate loss of 43,780 working hours. The April returns show 407 cases, of which 194 were for bad time-keeping, the loss of time involved being 18,922 hours. In another case tried at the Birmingham tribunal one of four men prosecuted for absenting himself from work complained that although his takings were six guineas per week he was engaged on skilled work in company, apparently, with a tailor. He asserted that in his own trade of filer for sporting gun actions he would have received 20*l.* for the same number of hours worked.

A protest against the failure of the authorities to utilise the Birmingham Proof House was made last week at the annual meeting of the Birmingham gun trade. The chairman, Mr. L. B. Taylor, observed that the military weapons now being made by the Birmingham gun trade were proved at the Government's own establishments. This condition of affairs constituted a real grievance to the Proof House Guardians and the trade. Proof houses were established in Birmingham and London by Act of Parliament, and, whatever the conditions, must be carried on. Had use been made of the Birmingham Proof House, a considerable saving of expenditure would, he said, have been effected. The Birmingham gun trade had, moreover, trained a large body of skilled artificers, who had proved most useful in the time of war as gauge-makers in their own factories or gone elsewhere to form the nucleus in starting important industries. They had also provided armourers for the front, and yet, after all this, they were told they were a non-essential industry. At least, so they were classified, he understood, under the National Service Act.

At the customary meeting, held last week, of the Durham Conciliation Board it was announced that the existing rate of wages for miners would be maintained during the forthcoming quarter. The rate is 107½ per cent. above the standard of 1879.

The Dutch Overseas Trust announce that the British Government is stopping further exports of cotton from this country, as the whole import is needed for our own requirements.

The Controller of the Foreign Trade Department has issued a new Consolidating List giving names of over 2,000 persons and firms with whom persons in the United Kingdom are forbidden to trade under the Trading with the Enemy Proclamation, 1916. Although the Statutory List has now been in existence for a year, cases still come to the notice of the Foreign Trade Department in which firms are corresponding with persons on the Statutory List. It is important that everyone engaged in foreign trade should realise that he is under an obligation to make himself familiar with the Statutory List and to observe it in his dealings. Failure in this respect renders him liable to heavy penalties. In exceptional cases where it appears to be necessary, and where it is not contrary to the public interest, a licence may be obtained from the Foreign Trade Department exempting from the prohibition. The Department is collecting information from British consular officers abroad in reference to firms in neutral countries with whom British houses could trade, in place of firms of enemy origin or association which have been placed on the Statutory List. The following bodies have agreed to disseminate the information :—The Association of Chambers of Commerce of the United Kingdom and its associate Chambers of Commerce, the London Chamber of Commerce, the Federation of British Industries, and certain approved trade associations and federations not associate members of any of the above organisations.

With a view to enlisting in greater measure than heretofore the advice and assistance of employers and workpeople in the working of the Employment Exchanges throughout the country, the Minister of Labour has decided to set up Advisory Committees in connection with each exchange (or small group of exchanges), consisting of persons nominated by associations of employers and workpeople, together with a small number of members directly appointed by the Minister. These committees will not be limited to the consideration of matters referred to them by the Department, and it is proposed that they shall be charged in due course with important functions in connection with the return to civil employment of discharged soldiers and sailors after the war. In view of the establishment of these new committees it is not proposed to call together again the Advisory Trade Committees already existing in connection with the Employment Exchanges, but the Minister acknowledges the great assistance which the chairman and members of these committees have rendered to the Department and expresses his sincere thanks for the services which they have given freely and unreservedly.

The accompanying award of the Conciliation and Arbitration Board for Government employees was issued during the week. This award grants a further war bonus to large classes of permanent Civil Servants whose claims have been heard before the Board by their representative associations, viz., the Civil Service Federation, the Civil Service Clerical Alliance, and the Customs and Excise Officers' Association. The award will cover the claims (amongst others) of the second division clerks, assistant clerks, the officers of customs and excise and women typists. It is understood that the Treasury have decided to extend the bonus to the whole of the permanent Civil Service who fall within the limits of remuneration and general conditions set out in the award. The award is substantially the same as that made to Post Office employees. It only applies to adult permanent employees (a further award being promised on the claims of temporary and juvenile employees); it becomes operative from January 1 last, and the chief features which distinguish it from the previous war bonus granted by the Treasury are the greater relative increase in the bonus granted to women and the extension of the limit of remuneration within which a bonus is granted from 165*l.* to 250*l.* a year. Its general effect will be that adult permanent civil servants will become entitled, as from January 1 last, to a temporary war bonus at the following rates :—

	Men. Per Week.	Women. Per Week.
Those whose pay is 30*s.* a week or under	9*s.* (previously 4*s.*)	6*s.* (previously 2*s.*)
Those whose pay is between 30*s.* a week and 40*s.* a week	8*s.* (previously 4*s.*)	5*s.* (previously 2*s.*)
Those whose pay is between 40*s.* a week and 60*s.* a week	7*s.* (previously 3*s.*)	4*s.* 6*d.* (previously 1*s.* 6*d.*)
Those whose pay is between 60*s.* a week and 250*l.* a year	5*s.* (nothing previously)	3*s.* 6*d.* (nothing previously)

A special conference of the Northern Counties Textile Trades Federation was held last Saturday at the Caxton Hall, Salford, "to consider the replies of the spinners and manufacturers (North and North-East Lancashire) refusing an application for an advance of 20 per cent. on the wages of all sections, and a minimum fall-back wage of 45*s.* per week to overlookers; to consider also the refusal of the Spinners' Federation (South Lancashire) and the Hard Waste Manufacturers to grant our application for a 20 per cent. increase in wages for all sections." The following recommendation of the Central Board was passed :—"That, failing a settlement of the questions, our members cease work on Saturday, May 26." The employers claim that owing to the increased prices of materials and the present state of the industry they cannot afford to pay higher wages, and that about 20 per cent. of the looms have already stopped from bad trade and other causes.

At the annual conference of the North Wales Quarrymen's Union, held at Bethesda last Monday, the president referred to the improved state of relationship with the employers. In former times, he said, the opening of negotiations was tantamount to precipitating a fight. The union has co-operated with the Welsh National Service Commissioners in the transfer of slate quarrymen to iron mining and limestone quarrying, both of these commodities being urgently needed for national ends.

The National Joint Committee of the Postal Telegraph Societies has accepted the new scale of war bonuses granted last week by the arbitration board.

An important decision was given last week by Mr. Justice Atkin in the Munitions Tribunals Appeal Court. Certain Sunderland shipyard riveters had been prevented by stress of weather from working for more than two days. They applied accordingly for leaving certificates on the ground that their employers had for more than two days failed to give them an opportunity of earning wages. The court's decision was in favour of the men, so that shipbuilders must in future be liable to pay men for idle time beyond two days

caused by the weather or run the risk of a stoppage of work by wholesale applications for leaving certificates.

In a paper read before the Society of Arts last Wednesday Professor W. Ripper discussed the question of works organisation and efficiency, taking as his text the following observations made by a workman at a recent joint conference:—"You employers are rich and comfortable, and the workers are, or were before the war, in want of all those things which go to make life really worth living. We demand that the present war-time wages shall continue after the war, and I want to ask you employers: 'Are you going to agree to a reduction of your profits; are you going to be willing to sacrifice some of your large incomes in order that the workmen may retain a decent living wage and continue the better home conditions which they have been recently enjoying?' I cannot see," he said, "how the men can continue to receive higher wages without injuring their employers, nor how it is possible, therefore, to avoid industrial trouble when the war is over."

The views expressed above as to the enormous profits made by employers in normal times appear to be very generally held amongst workmen. Undoubtedly some employers make fortunes, but, as Bacon observed three centuries ago, men count when they hit, and not when they miss, and workmen commonly take no note of the enormous sums lost yearly in the financing of industries. In any case the census of production showed that the capital invested per head employed in the engineering industry was only some 200*l.*, on which the return in pre-war times did not average 5 per cent. It is obvious, therefore, that if the whole of the receipts obtained by capital were divided up amongst the hands employed no substantial improvement in the standard of living would be effected.

As Professor Ripper pointed out in his lecture, the path of salvation lies in a different direction. Unless output per head is increased, the average standard of living cannot be raised. It may be added that this will in many cases require an increase in the capital invested per head, and this capital must be attracted by reasonable returns or it will not be forthcoming. Equally essential will be a great increase in the so-called "non-productive" expenditure, as our industries have in the past been much understaffed. Foremen and draughtsmen have been overworked and underpaid. Professor Ripper, for his part, laid most stress on specialisation and organisation, and undoubtedly there is much to be done in this field, both in the shops and in the markets.

MOTOR CAR VALVE STEAM LUBRICATOR.—We have received from Messrs. Brown Brothers, Limited, of 22 to 34, Great Eastern-street, London, a sample of Joseph's valve stem lubricators. It consists of a short pipe of fibrous material, apparently cotton, surrounded by a light spiral spring, the last coil of the spring at each end being attached by sewing or darning to the end of the pipe. The lubricator is, in effect, a spiral spring with a fibrous lining, and after the latter has been soaked in oil the whole is slipped over the valve spindle, inside the valve spring. As the valve stem works up and down the lubricant finds its way up the valve guide, making the valve work smoothly and quietly, and ensuring that it shuts promptly.

"THE SHIPPING WORLD" YEAR BOOK.—This, the thirty-first edition of this invaluable reference work, has been issued under the serious disadvantages entailed by the war. This has necessitated the omission of some customary features of the general section. The changes in the Government, the War Cabinet, the Blockade Department and the Controller of Shipping have necessitated sweeping revisions of the previous text, which have been duly attended to. The data in the port and harbour directory have been amplified and corrected up to the moment of going to press. The information as to national tariffs has also been revised, and particulars are given of the new tariffs for Chili and Mexico, and of the new import duties in British India. In spite of present difficulties the high standard of previous years is fully maintained in the new issue.

LIVERPOOL SHIPPING.—The 1917 edition of the handbook on Liverpool Shipping, published by *The Journal of Commerce*, has just been issued at the price of 1*s.* 3*d.* It contains a directory of the shipowners of Manchester and Liverpool, including in the case of companies the names of the principal officials, to which, in many cases, are added interesting historical and financial notes and data as to the services maintained. The official section of the handbook gives particulars of the present constitution of the Admiralty, the Board of Trade and Trinity House, with additional data about such bodies as the Shipping Federation and the local Chambers of Commerce. In the technical section are included notes on Lloyd's Registry, the British Corporation and the Bureau Veritas. Much information is also given concerning the works controlled by the Mersey Docks and Harbour Board.

THE LATE MR. HARRY RIGBY.

THE announcement of the death of Mr. Harry Rigby, which occurred last Monday, will be read with feelings of deep regret by a large number of engineers, especially those interested in constructional steelwork of an important character. For more than 30 years he had been associated with the firm of Messrs. Joseph Westwood and Co., Millwall, London, having occupied successively the offices of chief engineer and assistant manager, chief engineer and manager, and general manager and engineer. During that period he had carried out most important contracts, including large span bridges, stations, warehouses, and other structures in a way that had gained for himself and for his firm the confidence and esteem of engineers not only at home, but also in many parts of the world. Although acting mainly as the representative of a contracting firm he did much original work in designing, and contributed not a little to the successful carrying out of works for which he claimed no public credit.

Mr. Rigby had not completed his 61st year, having been born on July 18, 1856. His education was conducted privately and, in a scholastic sense, ended somewhat early, for in 1871 he was working in the drawing office of Messrs. A. Muir and Co., of Salford. His stay there was brief, for in 1872 and 1873 he became a pupil under his brother, Mr. William A. Rigby, the chief engineer to Messrs. Morewood and Co., Bilston, being employed both in the drawing office and shops. After two years Mr. Rigby was transferred as a pupil to Mr. R. C. Braithwaite, chief engineer and manager of the Old Park Works of the Patent Shaft and Axletree Company, Wednesbury. Here more important work was put under his charge, including the construction of the River Murray Bridge for Australia, which weighed about 2,000 tons.

His six years of training being now completed, Mr. Rigby became assistant engineer at the same works, where he remained until 1883. He took his full share both of actual construction and also of calculation and design, and for a time was resident engineer on the erection of the large Broad-street goods warehouse for the London and North-Western Railway, which involved 8,000 tons of ironwork. Mr. Rigby designed the present Brighton station for the acting engineer, Mr. Wallace, made all the calculations, detailed drawings, &c., and carried the work out as resident engineer for the Patent Shaft and Axletree Company.

In 1883 Mr. Rigby became chief engineer to Messrs. Eastwood, Swingler and Co., of Derby, with whom he remained three years, leaving to join Messrs. Westwood and Co., as already mentioned. He brought with him 15 years of experience gathered on a wide field, and turned it to most excellent account. Under his guidance the firm completed an immense amount of first-class work, while he made many professional friends, alike by his ability and his commercial probity. He had been a member of the Institution of Civil Engineers since 1910, although eligible as a candidate for election at a much earlier date.

TIMBER FOR SHIPBUILDING.—We learn from *The Engineering News* that the Grand Trunk Pacific Railway is hauling timber right across the North American continent on a passenger schedule. A large number of standard wooden ships of 3,600 tons capacity are being built.

THE COLOURS OF MOTHER-OF-PEARL.—The quantitative examination of the problem of the beautiful colours displayed by mother-of-pearl, the nature of which was recognised by David Brewster in 1853, seems to have been left to the United States Bureau of Fisheries. On behalf of this Bureau Mr. A. H. Pfund has conducted a research (Journal of the Franklin Institute, April, 1917), from which it appears that underlying the outer horny layer of some shells are small crystals of calcium carbonate separated by thin layers of conchiolin, the organic substance which forms the horny coating; underneath this prismatic layer, again, is the nacre, finer laminæ of calcium carbonate and of conchiolin in great regularity. When the two outer layers are removed the edges of the laminæ are exposed in steps like a grating, and there may be from 6,000 to 20,000 lines (or laminæ) to the inch, as there are about 14,000 lines in ordinary gratings. If these laminæ were not bent like the shell itself, scientists might make use of them. The study was conducted by making a celluloid replica of the surface, polished by means of a buffing wheel; celluloid dissolved in amyl acetate is poured on the shell, the acetate evaporated, and the shell is then placed in water for 20 minutes, when the replica can be pulled off. The grating structure and diffraction cause the iridescence of the shell. There are further colours, changing with the angle at which a spot is viewed; they are due to the interference between rays reflected by the parallel laminæ, which appear to be from 0.4 μ to 0.6 μ in thickness; that is to say, the thickness is about equal to the wave-length of greenish light. The great number of the laminæ and their extreme regularity of the structure have not been sufficiently studied by biologists yet. The organic substance conchiolin, we should add, can be isolated by dissolving the calcium carbonate in the shells in hydrochloric acid.

"SPONTANEOUS FRACTURE OF BRASS."

TO THE EDITOR OF ENGINEERING.

SIR,—The above subject, on page 426 of your May 4 issue, is particularly interesting.

I have experienced, casting round 60 : 40 brass bars, 7 ft. by 2¼ in.—in iron moulds—similar cracks running across and longitudinally, quite sufficient to make the bar scrap.

In the particular moulds the cracks would occur however quickly the bar was taken out after pouring, although at times only seen under magnification. This trouble immediately stopped on treating the moulds—but it appears evident that a much-used iron mould strains a bar considerably, even causing minute fractures, which will remain as such under any subsequent treatment in the cold.

I wonder whether this nuisance has any relationship to "Spontaneous Fracture of Brass."

Yours faithfully,

J. CLIFFE.

22A, Great Brook-street, Birmingham, May 7, 1917.

IMPERIAL PREFERENCE IN TRADE.

TO THE EDITOR OF ENGINEERING.

SIR,—It is nearly two months since I asked "A Student of History" to give his authority for saying that Austrian manufacturers of pencils got a home trade which enabled them to reduce their working costs and to produce a cheaper article than our English makers could put on the market; and, in the absence of any reply, I suppose we may conclude that "A Student of History" is mistaken. The last time I was in Austria the "home trade" in pencils had been secured by Japan at four a penny; and I have a sample of these pencils!

I trust that the question of Imperial Preference will not be allowed to drop, for it is of great importance to producers as well as to consumers; and the latter, who form the great majority in this country, do not get much consideration from tariff reformers, who find it easier to abuse foreigners than to make good articles at a reasonable price.

A STUDENT OF POLITICAL ECONOMY.

May 5, 1917.

COAL IN SWITZERLAND.—Switzerland is generally assumed to be devoid of coal, but Dr. L. Wehrli, a geologist, of Zürich, has recently issued a pamphlet in which he expresses the opinion that some workable beds exist. There is no coal, he admits, in the Jura district and in central Switzerland. The Bernese Oberland contained some coal, which has already been mined. A search in the Simmen Valley towards the Lake of Thun and beyond might, however, prove profitable, and there are indications of anthracite in the Canton Le Valais. This anthracite might amount to 30,000,000 tons, and if half of that amount could be mined, Switzerland could cover its own coal demand for five years.

LIQUID CHLORINE FOR STERILISING WATER.—In a paper read by Mr. M. S. Dutton before the Illinois Section of the American Waterworks Association it was stated that with hypochlorite at 7 cents and liquid chlorine at 20 cents the average cost of hypochlorite treatment at Laurenceville, Ill., during January was 107 cents per million gallons treated, against 28 cents for liquid chlorine. The results were also better with the chlorine, the bacteria count on nutrient agar being 11, against 15, from a worse raw water. There were no specimens of *b. coli* found in 1 cm. samples of filtered water with the chlorine disinfection. Only half the quantity of actual chlorine was used in the liquid form compared with that in the hypochlorite.

FLEXIBILITY OF HEATED WIRES.—The determination of the flexibility of hot wires cannot be effected by rough bending tests, in which too much depends upon accidental features. The apparatus which Dr. Lautz of the Charlottenburg Technical High School, devised for this purpose is far from simple. He pushes a short cylindrical sleeve over the vertical wire, at such a height that the wire, which is clamped, would just rest on the jaws of the clamp when bent to the right or left; the inner edge of the sleeve is rounded off, so that the bending wire is not cut by the sleeve. The lever which effects the bending can also be turned about the vertical axis of the wire; the bending may thus be effected in all directions. Below the clamp is the oil bath in which the wire is heated up to 320 deg. C. The number of bendings which the wire undergoes before breaking is automatically recorded. When the experiments were made it was found that in spite of the special precautions adopted the wire developed a kink or a swelling just below the sleeve; the sleeve was hence provided with sharp edges again, instead of rounded edges. The tests, described in the *Zeitschrift des Vereins Deutscher Ingenieure*, of September 26, 1916, showed that iron wire becomes more flexible up to about 220 deg. C. (the temperature varied with the material), when the flexibility may be double that at ordinary temperature, but decreases then to one-fifth the original value at 320 deg.; the flexibility maxima were less distinct in drawn than in annealed wires, and were by 10 deg. or 20 deg. C. higher in the former case; annealing is advisable to secure high flexibility. Copper wire proved less flexible than iron at ordinary temperature, but the flexibility increased speedily as the temperature rose. Thus the iron curves were irregular, those of copper quite smooth. Some 4,000 wires also, of lead, were tested, and the influence of bending at various temperatures, followed by bending in the cold, is to be further investigated.

DOUBLE-ACTING HORIZONTAL MULTIPLE DRILLING MACHINE.

CONSTRUCTED BY THE LANGELIER MANUFACTURING COMPANY, PROVIDENCE, R.I., U.S.A.

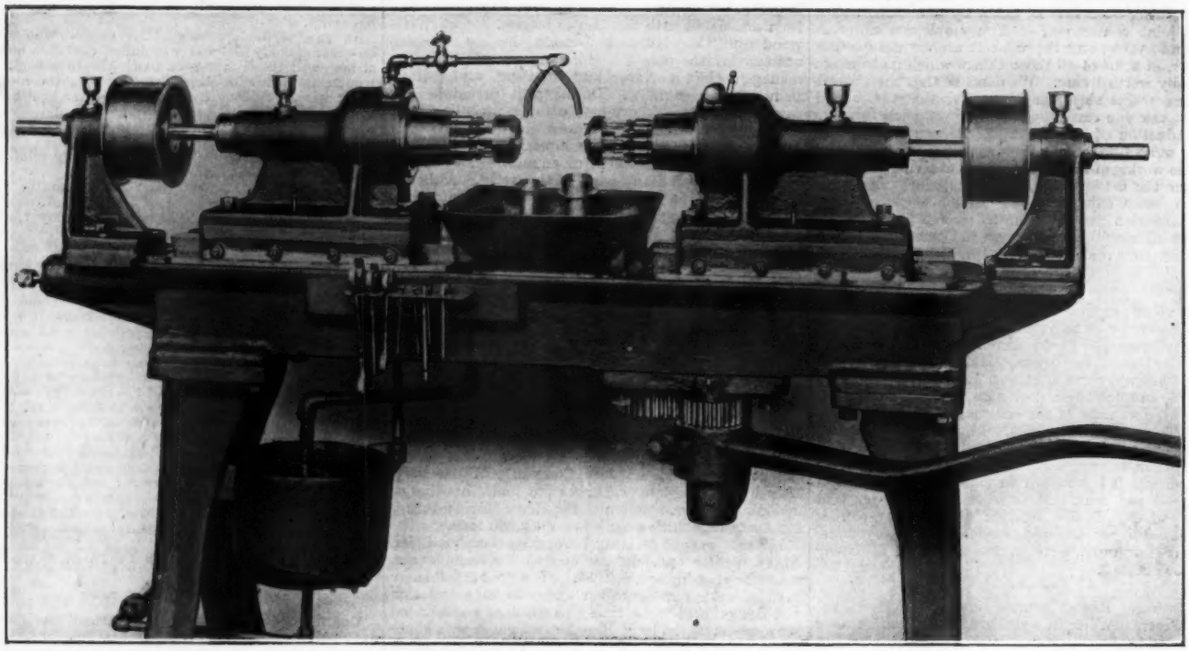
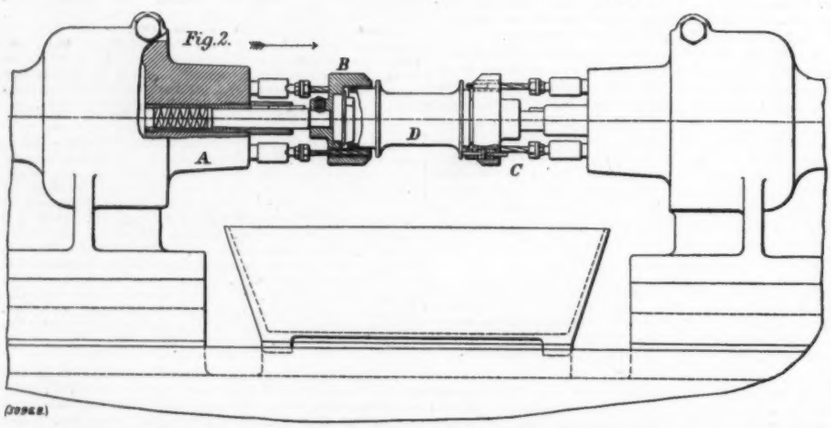
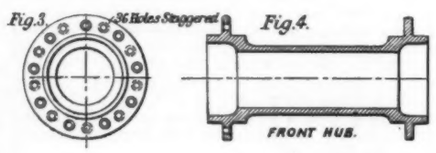
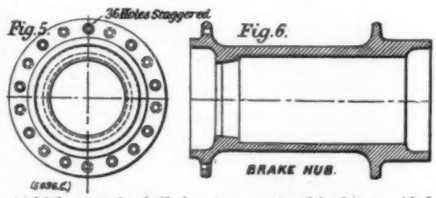


FIG. 1.







THE above engravings illustrate a type of double-acting horizontal multiple drilling machine recently brought out by the Langelier Manufacturing Company, of Providence, Rhode Island, U.S.A. This machine was designed for drilling such parts as motor-cycle, bicycle and side-car hubs, or for any cylindrical parts requiring one or several holes at opposite ends.

The machine is of simple design and well arranged for convenient operation. The multiple heads, which are interchangeable, are carried in sliding housings, both of which are actuated simultaneously by a single hand-feed lever, compounded to obtain the required leverage. The drive is transmitted through floating pulleys mounted in brackets at either end of the bed. A double-splined spindle slides in each pulley delivering drive to the multiple heads, thus permitting free motion to the housings. This construction eliminates all belt pull on the spindles, so that they carry no other load than that of driving the heads.

The jigging is simple and remarkably rapid. The jigs—one at each multiple head—are self-contained with the heads, being located by a central keyed spring plunger. The jig on the right-hand head contains an indexing device. Slipping the work loosely into either jig, the heads are brought together by a movement of the feed lever. This clamps the work between the jigs, while, continuing the travel of the heads, it feeds the drills into and through the work, the spring plungers receding into the heads. As the holes are on very close centres, only every alternate hole is drilled at one operation. Withdrawing the drills, the work is indexed by a twist of the wrist, a spring plunger engaging one of the holes already drilled; a second operation then completes the circle.

A new piece may be inserted the instant the drills are withdrawn, as the open construction permits the finished piece to drop into the chip pan, whence it may be removed while the following piece is being drilled.

The machine shown drills two sizes of hubs, so that two sets of interchangeable heads are provided. The unit construction of the heads practically eliminates any setting up, as the heads may be interchanged in a few minutes. By test, the first three samples drilled were finished within one minute, there being a total of 36 holes per hub, using a 39 drill. This is at the rate of 6,480 holes per hour. Micrometer adjustment is provided to the drills by means of adjustable collets, while a single adjustable stop, shown at the left-hand end of the machine, suffices for both heads.

Fig. 2 shows a section through the jigs for the rear or brake hub. The multiple head is contained in the sliding housing A. The jig B is carried on the plunger, which recedes into the head as shown. The index pin C is shown in the right-hand jig. The work D is located and held by the three-point centres, the springs having sufficient tension for a firm grip, while the several drills entirely neutralise any tendency to creep. Figs. 3 to 6 show respectively the front and rear hubs which are to be drilled. Automatic oil feed is provided, driven from an overhead countershaft, which is furnished with the machine.

While peculiarly suited to the class of work described, the machine may readily be adapted to a very wide range of work of practically any shape within the capacity of the heads, as jigs may be attached to the bed in place of the chip pan shown.

THE LOSS OF CHANNEL STEAMERS.—The hospital ship Donegal, lately torpedoed, belonged to the Midland Railway Company; the Hibernia and the Anglia to the London and North-Western; the Duke of Albany to the Lancashire and Yorkshire and London and North-Western Joint Service; the Sussex to the London, Brighton and South Coast Railway; and the Queen to the Chatham and Dover. The Brussels and Colchester of the Great Eastern Railway were captured by the enemy; while three vessels of the Great Central and two of the Lancashire and Yorkshire Company are detained in Hamburg.

TIMBER IN FINLAND.—The stock of sawn timber in Finland, according to the *Anglo-Norwegian Trade Journal*, was, on December 31, 884,164 standards. During the six months from December 1, 1916, to May 31, 1917, it was estimated that 170,269 standards would be sawn, and that the stocks on June 1, 1917, will total 1,054,433 standards. The estimated output of the present year is 200,000 standards. On December 1 last there were in stock 17,511,545 logs, and the estimated felling during the winter season is 7,917,000 logs. The annual growth of timber in Finland is approximately 35,000,000 cub. m., and the annual felling 37,000,000 cub. m.

THE DETERIORATION OF TURBINE BLADING.*

By Mr. A. Fenwick.

(*Concluded from page* 423.)

Guide Blading.—In introducing the subject of deterioration of these blades, it will be as well to commence with a description of what actually happens to the blade, and afterwards take a few typical cases. 30 per cent. to 32 per cent. nickel steel (J) is the material in general use, and, unless otherwise stated, the deterioration refers to this material. The nature of the deterioration is the same in all cases, but the results, taken over a given period, are quite inconsistent, and vary considerably with different turbines in the same station, and show a still greater difference with similar machines at different stations. The first visible indication appears in the form of a fine crack, always on the inlet side of the blade, and frequently close to the outer retaining ring, but sometimes near the centre of the blade. Before these cracks are actually visible they can be produced by a few light hammer taps. These cracks extend over the surface of the blade, cobweb fashion, until pieces become detached and pass through the succeeding stages, severely bruising and closing up the wheel blading on the inlet side, but seldom causing a strip; the amount of damage done is naturally regulated by the size of the broken piece. All blades in the guide ring are not affected at once; generally, isolated blades distributed round the ring develop these cracks, but often the defective blades appear in batches; ultimately the whole of the blades crack, and if not attended to the guide ring collapses, causing heavy fouling and serious damage to the wheels and blading.

Fig. 19, Plate XLVI, shows a portion of a guide blade diaphragm, the cracks in the blades being clearly visible; this had been in commission for 9,391 hours only, on one of the compressor turbines, Class 5, and failed a few months after this photograph was taken owing to lateral movement of the diaphragm having taken place in the direction of the following wheel, which was ultimately fouled.

Fig. 20 shows a portion of the upper half of the guide ring for the eighth stage removed from No. 5 generator turbine, Rosherville, after 7,801 hours. Reference to Table VI, (page 422 *ante*), giving the life of guide blades for Class 2 turbines, shows this to be due to mechanical damage caused by a partial strip; the mechanical damage is, however, slight, and an examination of the ring is interesting, nearly every blade being fractured where joining the inner and outer retaining rings. The photo is not clear, but the light splashes near the lower ring show where fracture has taken place, and, in addition, several blades have holes right through them, more particularly at the junction between the curved portion and the straight. The portion of blade clear of the retaining rings looks quite good until smartly tapped with a hammer, when the characteristic cracks showing early deterioration are produced. The lower half of this ring, which had only run 3,165 hours, was removed and carefully examined, but it was found to be quite sound.

Fig. 21 shows three loose guide blades from generator turbines, Rosherville, in various stages of deterioration. (*a*) (Specimen 2/15) was removed from seventh stage guide ring No. 2 set after 15,308 hours; (*b*) (specimen 4/15) from seventh stage No. 3 set after 18,023 hours; (*c*) (specimen 12/15) from twelfth stage No. 2 set after 19,887 hours. These blades are in the same condition as when in position in the guide ring, and have not been further damaged during removal. Fortunately, in the case of the guide blade rings under discussion, there is little danger when the cracks first appear, as several months elapse before pieces of guide blade break away. Examination at intervals of 3,000 hours allows one to follow the condition and judge when the ring should be renewed.

In the case of the guide blade diaphragms, as fitted to Class 4 and 5 turbines, they become unsafe as soon as cracks appear, and movement of the diaphragms in the direction of the following wheel has taken place on different occasions. This tendency to displacement of the diaphragm is probably due to the circumferential pitch of the blades in the guide blade diaphragm construction being greater than in the guide ring construction, with a consequent increase of diaphragm area per blade. The subjoined table gives the diaphragm area exposed to the difference of steam pressure between the inlet and discharge side, also the number of blades and pitch for the first set of guide blading, *i.e.*, for stage 2. Three classes of turbines are dealt with, the diameter being taken to the nearest inch. There are 12, 11 and 4 Rateau stages, in Classes 2, 4 and 5 turbines respectively, and assuming the pressure drop across each stage to be 6 lb. per square inch for the first two, and 12 lb. per square inch for the third, the weight carried per blade is shown in the right-hand column.

—	Area of Diaphragm.	No. of Blades.	Pitch of Blades.	Weight Carried per Blade.
	sq. in.		mm.	lb.
9,600-kw. turbines, Class 2	4,624	148	42.0	187
12,000-kw. turbines, Class 4	3,606	76	74.6	284
10,000-h.p. compressor turbines, Class 5 ..	2,109	52	84.0	486

* Paper read before the South African Institution of Engineers.

Fig. 22 shows the difference in the shape of the blades for a guide ring and a guide blade diaphragm. It will be noticed that the curved portion marked X is much longer in the former than in the latter construction.

With regard to the life of these blades, Table No. VI gives the number of running hours up to the time of replacement, if such has taken place, or up to September 30, 1916, if the original rings are still in use. All the turbines are of 9,600 kw. (Class 2), five being in use at Rosherville and four at Vereeniging. The conditions are generally the same at each station, with the exception of the steam temperature, which is 350 deg. C. at Vereeniging, as against 320 deg. C. at Rosherville. Reference to the table shows the great disparity in the running hours between the various stages at the same station, and the same stages at the two different stations.

First, it will be noticed that in no case has it been necessary to renew the first four guide rings owing to deterioration; in one case renewal has taken place; this was, however, due to mechanical damage owing to fouling some hard material, probably a piece of nozzle vane. It will also be noticed that deterioration commences first in stage 7 on the first five sets, and that the life varies from 9,900 hours on No. 1 to 18,023 on No. 3. As in the case of the wheel blading, the "life" does not represent the time the blades would actually have lasted; it simply shows that when renewed the blades were defective, the degree of deterioration varying considerably. Generally speaking, no rings were renewed until small pieces of blades broke away, and in some cases the rings were in an absolute state of collapse before being renewed.

Allowing for this difference in condition, however, there is no satisfactory reason to account for a difference of over 8,000 hours in the life of stage 7 on sets 1 and 3. The variation in the life of the centre stages on the Rosherville and Vereeniging sets is very marked, and before attempting to explain this it will be well to consider possible causes for this deterioration.

Influence of Material on Deterioration.—The evidence is hardly sufficient to state definitely the relative advantages of high or low percentage nickel steel, but the results obtained in No. 4 set, Rosherville, point to steel containing no nickel as being more suitable. Stages 6 to 13 on No. 4 were tested in exactly the same manner, *i.e.*, they were struck sufficiently hard with the ball of a hammer to indent the blade in several places where exposed at the horizontal joint. Cracks could only be produced on stages 7 and 12, which on analysis were found to contain 30 per cent. nickel; the other stages resisted this somewhat drastic treatment, and these blades were marked H by the makers and found to contain no nickel. When last examined there was a good deal of pitting on the convex and concave portions of these H blades, which effect is unusual with the nickel steel blades.

We are experimenting with different classes of steel; Siemens-Martin, and 5 per cent. and 3 per cent. nickel steel being at present in use, cast into the retaining rings in a similar manner to that adopted by the makers. The test is of far too short a duration to form an opinion as to the respective merits of these various steels, and the time required is one of the drawbacks to these experiments, as, even when the turbine is run at a very high load factor, two and a half to three years must elapse before we can say that a definite improvement has been made, unless, of course, the steel on trial gives much worse results than that at present in general use.

On the Class 4 turbines H steel, containing no nickel, has been supplied for some stages, and has so far shown no deterioration, while other stages, containing 30 per cent. nickel (J steel) in the same machine have shown marked deterioration, but these will be referred to later.

In the case of the guide ring renewed on No. 4 set, Vereeniging (stage 10), some of the blades were badly cracked, and others appeared to be in perfect condition; one of each was analysed, and both were found to be 30 per cent. nickel steel, the inference being that the presence of a high percentage of nickel does not necessarily cause the blades to crack.

A non-ferrous material might be tried with good results. The cost would be a good deal higher than if steel were used, but that would not matter much if the life were considerably increased. Casting iron round blades made from Monel metal sheet has been tried, but the heat of the molten metal appears to take the nature out of the copper-nickel alloy, rendering it short, so that it cracks and breaks on bending.

Mechanical Stresses imposed on the Blades by Expansion and Permanent Growth of the Retaining Rings and Diaphragms and by Sudden Changes of Temperature in the Blades.—We have ample evidence of the exceedingly heavy stress imposed on the blades from this cause, particularly at the high-temperature end of the turbine.

When the machines were first erected the guide rings were fitted to a groove in the casing, and secured thereby by means of screws; the C.I. diaphragm, of dished formation, is grooved round the periphery and fitted snug to the inner retaining ring of the guide ring, there being a corresponding tongue fitting the groove of the diaphragm to prevent lateral movement. The convex side of the diaphragm is toward the high-pressure end of the machine, and is designed to resist the difference of pressure between the inlet and discharge side of the guide rings. It may have been assumed by the makers that this dishing would relieve the blades of excessive stress by deformation of the casting, and the latter effect actually occurs, as it is found that the clearance between the diaphragm boss and the preceding wheel gradually diminishes. It, however, does not relieve the blades sufficiently to prevent severe buckling of the first two rings, and Fig. 23 shows this very clearly. Photographs of the 9,600-kw. machines are not available, but the figure shows a portion of a stage 2 ring removed from one of the Simmer Pan 3,000-kw. sets, the deformation of the blades in the larger sets being similar, although not usually quite so pronounced.

In addition to the buckling of the blades, they are badly cracked, as seen in Fig. 24, due doubtless to the enormous stress imposed. This particular ring was in commission for 39,000 hours, and is the first one renewed on the early stages of the machine owing to cracked blades. On the 9,600-kw. sets these cracks have not yet appeared on the first five stages.

It is seldom the blades are buckled beyond the third guide ring, the expansion of the guide rings and diaphragms being naturally less as the temperature decreases, until at the exhaust end it is comparatively low, seldom exceeding 50 deg. C. If we assume heavy pressure on the blades to be the cause of the cracking, it seems strange that where the pressure is heaviest the blades are least affected. It may be a contributory cause, but in any case it is obviously better to relieve the blades of this stress as far as possible, and this has been accomplished in the case of the guide rings by machining a 3 mm. clearance between the guide ring and diaphragm and resting the diaphragm on two short fitting strips on the lower half. A few copper pins are fitted on the upper half of the guide ring, with about 0.5 mm. clearance between the pins and diaphragms, so that the latter cannot rise too much and foul the shaft gland. It is found that after a time these pins are crushed by the diaphragm, and they are eased periodically.

In the case of the guide blade diaphragms these are suspended on lugs at each side of the turbine casing, 3 mm. clearance being left all round the casing groove, so that the diaphragm is free to move when fitted, but gradually tightens sideways in the groove as the growth of metal takes place.

Reference to the notes in remarks column of Table VI shows that in sets 1 and 2, Rosherville, cracked blades are found in the eighth stage after 8,700 and 9,700 hours. Also in the eighth stage of No. 5 set, Rosherville, after 7,801 hours. These three rings were eased when first fitted and have never been subjected to heavy pressure. It therefore seems clear that the metal deteriorates irrespective of the compression to which the blades are subjected.

In the case of the guide blade diaphragms on turbines Classes 4 and 5, which were fitted to relieve blade stresses, 1 mm. clearance was left round the circumference by the erectors. This was absorbed during the first year of running, and, in addition, in some cases, very heavy distortion has taken place.

Fig. 25 shows the guide blade diaphragm for the second stage on one of the 12,000-kw. sets installed at Brakpan in 1915, and the photograph was taken after 8,822 running hours (14 months). The rim of the diaphragm portion should be flush with the top side of the outer retaining ring, but has moved $\frac{1}{8}$ in. toward the following stage, shown by the dotted line. In addition, practically every blade is cracked, this being the first instance which has occurred at such an early stage in the machine after such a short life; the material is 30 per cent. nickel steel, 2 mm. thick. In this case the clearance was most likely very soon taken up, and the heavy pressure doubtless had much to do with the cracking and was mainly responsible for the distortion.

Finally, we have cases on record where long life has been attained without the rings being eased at all. On one of the 3,000-kw. sets installed at Brakpan some of the blading was renewed after 46,890 hours (stages 2, 6, 7), and on the adjoining set the blading was eased after over 40,000 hours, and is still in commission and in good condition after 59,000 hours, with the exception of the guide ring for stage 2, the blades of which are now cracking. In both machines the blades are of J steel. The steam temperature at the stop valve has been somewhat lower on these sets, being about 290 deg. C., as against 320 deg. C. to 350 deg. C. on the sets previously dealt with. This difference in life is most difficult to account for. Some makers use steel castings for turbine diaphragms, and this material possesses an advantage over cast-iron in that it is not, as far as the author is aware, subject to permanent growth to the same extent as the latter material.

With regard to the sudden expansion of the blades themselves when starting up a set from a cold state, the blades are thin and will temporarily attain a higher temperature than the retaining rings; they will be subjected to compression stresses on this account, although 30 per cent. nickel steel probably has a very low coefficient of expansion; 36 per cent. nickel steel (invar), used for instrument work, has no coefficient of expansion.

In this connection the number of starts over an extended period have been examined on the various 9,600 kw. sets, but this does not seem to have any bearing on the life of the blades, and it is probable that these stresses are not so serious as others which the blades are called upon to withstand.

It having been decided to cast these guide blade rings locally, their manufacture presented some difficulty at first, and previous to the work being put in hand some of the old guide rings were rebladed as an emergency measure. Ordinary steel plate, 2 and 3 mm. thick, was used, cut to shape and bent round a former. The blades were then flanged and riveted between the retaining rings, a fairly neat job being made. Fig. 26 shows the blade ready for fixing. The blades were quite sound when last examined, but had only been in commission for 2,839 hours. It will be interesting to see whether this method of building up the rings will increase the life of the blades. There may be some advantage in the flanging, a little more elasticity, perhaps, and, further, the blades are not subjected to the intense heat which is unavoidable when the molten iron

is cast round them. It is significant that the turbine in which these rebladed rings are fitted is less efficient than the others of similar type. This may be due to the rivet heads and flanged portion of the blades, which project into the steam passage and obstruct the steam flow.

Other Stresses, Vibration, Impurities in the Steam, &c.—If we assume the drop in pressure across each diaphragm to be 6 lb. per square inch, and the diameter of the diaphragm to be 60 in., the guide blades have to withstand a lateral force of 8.4 tons, which, divided between the blades, may not be excessive. In addition, however well the machine is balanced, a certain amount of vibration will take place, due to the rotation of the parts, and also due to the passage of steam through the blading. This vibration, acting on the guide blades while under stress from the diaphragm pressure, and perhaps at a critical temperature, may cause cracks to develop and ultimately break down the material. Another factor which may influence deterioration and account for the difference in life at various stations is impurities carried over from the boilers with the steam. For instance, on the 3,000-kw. sets at Brakpan, where exceptionally long life has been attained, the boilers are supplying steam to reciprocating compressors, and oil used for lubricating the steam cylinders has found its way into the boilers, and from these to the turbines. It occurs here as a greasy deposit on the guide blades, which may have acted as a protective covering. The feed water make-up at this station was at one time strongly alkaline, being quite different from that at Rosherville or Simmer Pan, while at Vereeniging river water is used, which is comparatively soft.

Two final cases are given, which are interesting on account of the rapidity with which deterioration takes place, and also because the machines are of later design than those previously described. The first of these is one of the 12,000-kw. generator turbines installed at Brakpan, containing 11 guide blade diaphragms, the blades in the first seven being 2 mm. thick, of high percentage nickel steel J; of these the 1st, 6th and 7th contained blades so badly cracked after 8,822 hours as to be unsafe, while in the 5th the blades were just commencing to crack; in diaphragms 2, 3 and 4 the blades were quite sound; in the remaining four stages, beyond the 7th stage, the blades are of steel containing no nickel (H) and are in good condition; in three of these the blades are 3 mm. thick, and in the fourth and last 4 mm. thick. The first five stages on this set have been subjected to heavy pressure, so much so that displacement of the diaphragms has occurred, as shown in Fig. 25, previously described. It would appear from the above that the H steel, 3 mm. thick, will give better results than the 2 mm. J steel, although it is strange that in diaphragms 2, 3 and 4 the latter material shows no cracks; one can only conclude that there must be some difference in manufacture of the plates from which the blades are made, as the rough analysis shows the material to be similar, and the conditions are the same as on the diaphragms at either side.

The other case is on the three large compressor turbines of 10,000 h.p. installed at Rosherville.

There are five guide blade diaphragms in these sets, the first two containing H steel blades without nickel, 5 mm. thick on the inlet side, tapering to 2 mm. on the outlet side. These blades show no cracks after 11,000 hours. Diaphragms 3, 4 and 5 contain blades 2½ mm. thick, of uniform section, and on two sets diaphragm 3 has nickel steel (J) blades, which have both cracked badly after 10,000 and 11,000 hours respectively. On the third set blades containing no nickel (H) are used, and at present are quite sound after 6,000 hours. On the fourth diaphragm J steel has been used for compressors 8 and 9, and in both cases the blades have cracked after 11,000 and 6,000 hours respectively; while on compressor 7 H steel is used and is in good condition after 10,000 hours. J steel is used throughout for diaphragm 5, and when examined the blades were cracked in one case only.

The following table shows the arrangement of blades and condition when examined after the number of running hours specified. H signifies steel containing no nickel, and J 30 per cent. nickel steel:—

10,000-*h.p. Compressor Turbines.*

Diaphragm No.	No. 7. 10,362 hours.	No. 8. 11,543 hours.	No. 9. 5,994 hours.
1	H, steel good	H, steel good	H, steel good.
2	,,	,,	,,
3	J, cracked ..	J, badly cracked	H, good.
4	H, good ..	,,	J, slightly cracked.
5	J, good ..	J, cracked ..	H, good.

The above results point to H steel being a much more suitable metal for guide blading than J steel. No. 7 compressor has been opened up quite recently (since the above table was drawn up), and the guide blades have been hammer-tested severely. In the third diaphragm cracks in the blades are clearly visible before hammering, and with a few smart blows the cracks extend over the surface and pieces can be knocked out. The H steel blades, containing no nickel, used in diaphragm 4, were treated in the same manner, but no cracks were produced, the metal being quite sound. In diaphragm 5 no cracks were visible until the blades were struck a few times, when the cracks appeared, showing the metal to be in the early stages of deterioration. The guide blading was in commission for just over 13,000 hours when this examination took place.

A photomicrograph of the H steel in use is shown in Fig. 14, on Plate XLIII *ante*.

Conclusions.—In summarising the behaviour of the materials used in blading these turbines, it will be seen that there is no difficulty in choosing a material for moving blades which can be depended on to give fairly satisfactory results in particular stages. Five per cent. nickel steel, brass and aluminium bronze in suitable stages will have a life of 40,000 hours, and perhaps 50,000, or more, which, if the turbines are run continuously, means five or six years. It is probable that in the majority of power stations the running hours would be much less, and the number of years the blades would last will be correspondingly increased. One has to decide what constitutes a satisfactory life, and if we assume the turbine will be in use for 15 or 20 years, the ideal blade material is one which will do its work efficiently for this period. If long life can only be achieved by the use of expensive alloys, the cost of such material would have to be compared with the saving in maintenance which would result by its use.

With regard to the life of turbine plant, one has to consider the probability of future improvements, which might increase the efficiency of turbines to such an extent that it would pay to scrap existing plants and instal new ones.

One has to admit, however, that a very considerable advance in efficiency would have to be made to justify this course, and the uncertainty of a sufficient improvement is a further argument for better blading material.

A saving of 1 per cent. in coal consumption on a 10,000-kw set supplying 6,000,000 units per month may represent about 400*l.* per annum.

With regard to inlet nozzles, it is clear that no reasonable expense should be spared in making these absolutely reliable; nozzles with thin cast-iron vanes should be abolished, but if cast-iron is used the design should be such that there is no possibility of pieces becoming detached.

The guide blading in use on these turbines is clearly unsatisfactory, and the reader may wonder why this state of affairs has not been remedied long ago. The user is, however, largely in the hands of the turbine builder, and, further, if a mistake has been made in design or material in the original installation, three years or more must often elapse before this is discovered, and an equivalent time is taken to prove the success or otherwise of any alteration. Incidentally, thousands of pounds are spent by the user in large installations in renewing defective blading and making good damage caused by broken pieces, collapsed rings, &c. This maintenance should be unnecessary, and for this reason the defects have been given in considerable detail.

While the author feels that mild steel is preferable to the high-percentage nickel steel in use, it must be admitted that the latter has given good results in many cases. On the fourth diaphragm J steel has been used for the 10,000-h.p. compressors 8 and 9, and in both cases the blades cracked, while on compressor 7 H steel and is in good condition.

High percentage nickel steel has been more extensively used and for a much longer period than non-nickel steel. The latter material is in use on No. 4 generator turbine, Rosherville, and in this case considerable pitting has occurred. The evidence obtained on the 10,000 h.p. compressor turbine, Rosherville (No. 7), is, however, very much in favour of mild steel, and there seems little doubt that it will prove the better material. The possible causes of deterioration are not conclusive; they may all be contributory to the general failure, and the inconsistency of results, particularly at different stations, makes the whole subject very puzzling. One is inclined to blame 30 per cent. nickel steel because so much of it is in use and fails, and it may be that mild steel will also prove unsatisfactory through cracking or pitting.

Blades made from brass sheet and carefully fitted to retaining rings have been used for small turbines by some manufacturers, and various methods of attaching blades could be devised. The cast-in method used on the turbines described in this paper is, however, very simple and requires a minimum amount of machining and fitting, so that it would be preferable to retain this design if satisfactory results can be obtained.

The author believes that the position can be much improved by the use of thicker blades of mild or low-percentage nickel steel, say, $\frac{7}{16}$ in., or ½ in. tapered, perhaps, on the outlet side to ¼ in. Unfortunately an alteration of this kind on a ring designed for 2 mm. blades reduces the area for steam passage somewhat. To obtain the same port area the radial length of the guide blade would have to be greater, necessitating a longer moving blade. The following alterations have been made, which may result in a considerable improvement in the life of the guide blades.

In the case of the guide blade diaphragms for the 10,000-h.p. compressor turbines, in addition to substituting B, C and C1 steel for J steel, the blades have been increased in thickness from 2.25 mm. to 3 mm. in three diaphragms on one turbine without affecting the efficiency or output.

On the 12,000-kw. generator turbines at Simmer Pan and Brakpan six stiffening blades of mild steel, $\frac{7}{16}$ in. thick, have been cast in each half; these are distributed equally round the diaphragms and take the place of the J steel blades, 2 mm. thick, originally used. The remaining blades are 2 mm. thick, B, C and C1 steels being used in the various diaphragms.

On the same class of turbine another experiment is in hand; cast-iron stiffening blocks are being cast between adjacent guide blades on the horizontal and vertical diameters of the diaphragm. This blocks up four ports in the complete ring, and should stiffen up the diaphragm very considerably. In addition, the material has been changed from high-percentage nickel steel to B and C steel.

The guide blade diaphragms on which the last two experiments are being tried are not yet in commission, so that the effect on efficiency is at present unknown.

The author cannot say whether similar trouble is prevalent on turbines made by other firms, and any discussion which this paper may promote will be valuable in throwing light on the best design and material for turbine blading. It is hardly to be expected that manufacturers will advertise defects in their machines, but users need have no scruples in this respect.

In conclusion the author desires to thank the management of the Victoria Falls and Transvaal Power Company, Limited, for permission to publish the information contained in this paper, and also Messrs. C. W. R. Campbell and Val Davies for preparing the slides and photographs which accompany the paper.

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

WE give below a few data on several Colonial and foreign engineering projects, taken from *The Board of Trade Journal*. Further information on these projects can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C. 2.

Tasmania.—With reference to the notice on page 318 of *The Board of Trade Journal* of February 1, and to previous notices, relative to the Tasmanian hydro-electric installation scheme, which is in process of realisation, H.M. Trade Commissioner in Australia (Mr. G. T. Milne) has forwarded an extract from the local press containing a report by the manager of the Tasmanian Government hydro-electric undertakings concerning further projected schemes. In addition to the Great Lake and King River schemes, it is stated that others are likely to be put in hand. There will be no difficulty in developing on the West Coast itself all the power needed there, even if the demand grows much larger than is at present anticipated. Over 10,000 h.p. can be developed at Lake Rolleston, near Zeehan, and the Franklin River and other possible sources of power are now being prospected. Later, when copper is cheaper, an inter-connecting wire may be run from the West Coast to the Great Lake. In the central plateau region several schemes, quite apart from the Great Lake, are now being inquired into. It is thought that 40,000 h.p.—possibly more—can be developed on the river Derwent; the works will probably be some distance below Lake St. Clair, which will serve as a reservoir. The Arthur Lakes are a source which seems well able to yield 40,000 h.p. to 50,000 h.p. These schemes are likely to be held in abeyance for some time.

Russia.—H.M. Consul at Ekaterinburg (Mr. T. H. Preston) reports, under date March 4, that a local firm of engineers, who before the war dealt entirely and on a very large scale in German machinery and tools, has recently rented about 121 acres of land in the vicinity of Ekaterinburg, on which it is proposed to erect large metallurgical works. The erection of these works, it is stated, has been decided upon after tests with Ural iron had been made abroad, which gave excellent results. The name of the firm referred to may be obtained by British firms interested on application to the Department of Commercial Intelligence, 73, Basinghall-street, London, E.C. 2. In making application the reference number (177) should be quoted.

Norway.—According to a report to his Government by the United States Consul-General at Christiania, published in *Commerce Reports* (Washington) of March 27, the Norwegian Government has recently been advised by a committee of the Storthing not to allow foreigners or foreign companies to acquire waterfalls in Norway, except in special circumstances. The power contained in the Norwegian waterfalls has been estimated at from 6,000,000 h.p. to 10,000,000 h.p., and the development of these falls has been accomplished largely through the aid of foreign capital. The acquisition of water power by foreigners in Norway is regulated by the Law of September 18, 1909, by the terms of which only the Norwegian Government or municipalities or Norwegian subjects were permitted to acquire waterfalls of more than 1,000 h.p. without Government sanction for each individual case. This law was made more stringent by the Law of August 4, 1911, which provided, *inter alia*, for a tax payable to the local authority and the State. A Royal Commission, which has been at work for several years on a revision of concession legislation, has just submitted to the Storthing a new Bill. Under this Bill it is proposed that foreign subjects and companies shall not be allowed to acquire concessions except in special cases, as, for instance, when an industrial concern already in operation wishes to acquire or regulate a waterfall. Joint stock and other limited liability companies must in future have an entirely Norwegian board, with registered offices in Norway, and exclusively Norwegian capital, in order to obtain permission to acquire waterfalls. In the case of mining property a concession period of not more than fifty years is proposed. The concessionaire must engage to satisfy certain social conditions. It is stated that an investigation made in 1909 showed that at that time 38 per cent. of the capital of industrial companies was in foreign hands; that 85 per cent. of the capital in electro-chemical undertakings was similarly held by foreigners; and that 80 per cent. of the capital invested in mining enterprise was foreign. Notices relative to the Laws of September 18, 1909, and August 4, 1911, appeared in the issues of *The Board of Trade Journal* of October 21, 1909 (page 132), and February 29, 1912 (page 469), respectively.